THE SCOTTISH HORTICULTURAL RESEARCH INSTITUTE

EIGHTH
ANNUAL REPORT

1960-1961

MYLNEFIELD, INVERGOWRIE, DUNDEE
Tel: INVERGOWRIE 441

WEST OF SCOTLAND UNIT
AUCHINCRUIVE, AYR
Tel: ANNBANK 293

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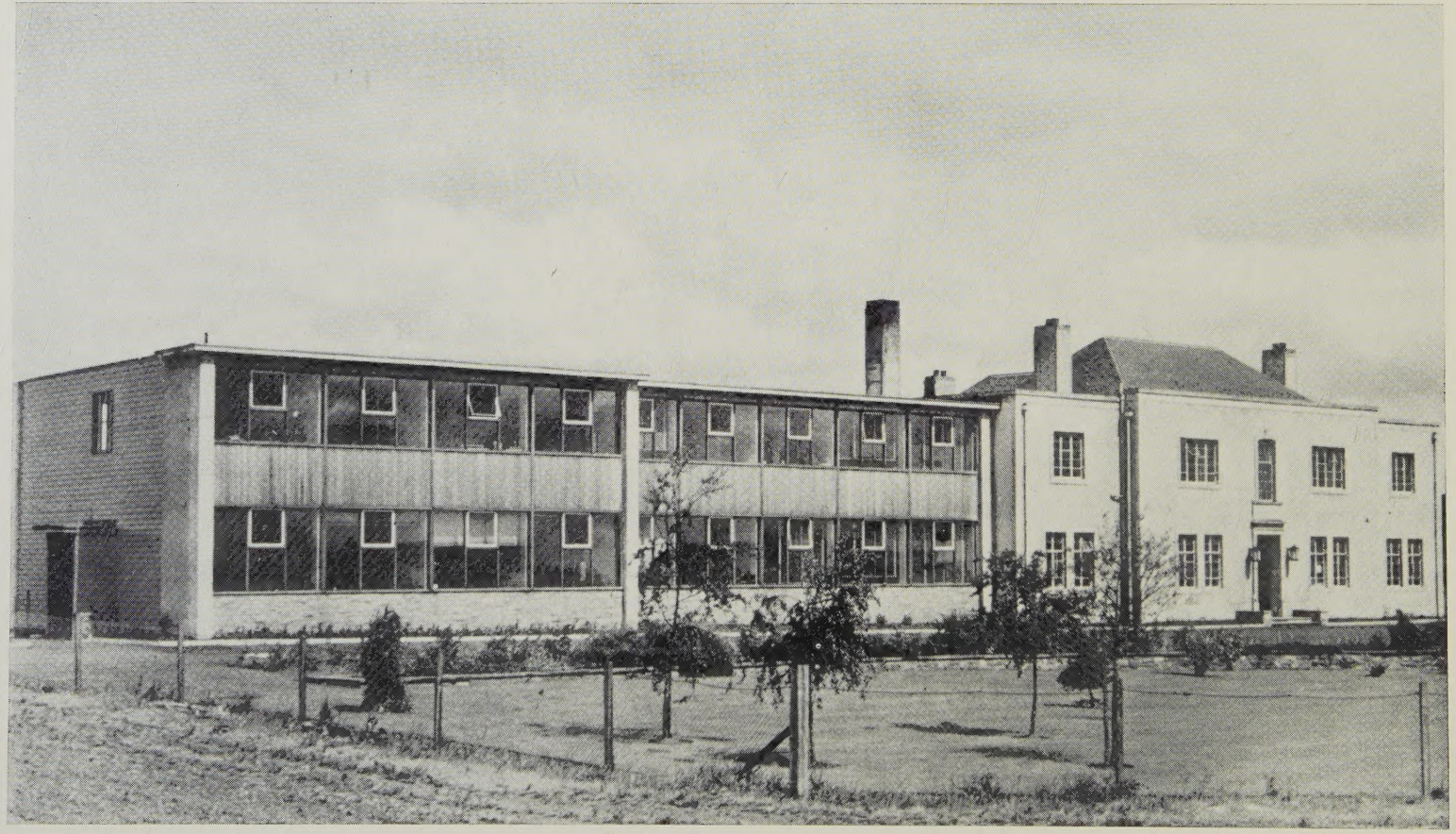

PHOTOGRAPH BY J. SUNDERLAND

THE SCOTTISH HORTICULTURAL RESEARCH INSTITUTE

Main laboratory and administrative buildings at Mylnefield, with the new west wing completed in 1960

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THE SCOTTISH HORTICULTURAL RESEARCH INSTITUTE

The Scottish Horticultural Research Institute was incorporated on 31st March, 1953, as a company limited by guarantee without share capital. The business of the Institute is managed by a Governing Body, the members of which are appointed by the Secretary of State for Scotland. The registered office is at Mylnefield, Invergowrie, Dundee. A West of Scotland Unit is located at Auchincruive, Ayr.

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W. I. A. JACK, *Foreman.*

† Honorary Lecturer in the University of Glasgow.

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THE DIRECTOR'S REPORT

There were two outstanding events during the year. One was the completion and occupation of the extension to the west wing of the main laboratory and administrative building, and the other the meeting at Mylnefield in July of some of the world's leading virologists to discuss the problems of soil-borne viruses. A special account of the Soil-borne Virus Symposium by Dr. Cadman appears later in this Report.

The new laboratory extension in effect completes the first phase of the Institute's building programme as it was envisaged at its inception in 1951. The basic structure is of reinforced concrete, and employs a ten-foot module. The internal walls are non-load-bearing, the load being carried on the reinforced concrete pillars. Should it ever become necessary, an almost complete internal reorganization will be possible provided that the new layout is based on the same module.

In addition to providing a substantial increase in laboratory accommodation in the form of units of varying size, this development has enabled nearly the whole of the research and administrative staff to be housed together in the one building. The new wing provides small individual rooms for Heads of Departments, a laboratory workshop and stores and a much-needed women's rest room. The electron microscope and centrifuges of the Virology Department and the photographic section of Laboratory Service are still housed in buildings across the courtyard, pending the provision of further accommodation in the main building. A photograph of the main Institute building with its completed extension forms the frontispiece of this Report.

THE YEAR 1960/61

The year was one of good general progress in the work of the Institute as a whole and of further valuable developments in particular sectors.

Reference has already been made to the prominence of the current work on soil-borne viruses. New advances are now reported in connection with the transmission of these viruses from plant to plant by soil-inhabiting nematodes and their dispersal in the seeds of their weed and other host plants.

Studies were continued on the effects of gibberellic acid and maleic hydrazide on the processes of growth and development of the strawberry plant, and an interesting investigation was begun on the part played by growth substances in the development of the fruit of the strawberry. Applied work associated with these and other physiological studies included further trials on the use of maleic hydrazide for the control of runner formation in strawberry fruiting beds, more experiments to measure the effect of post-harvest defoliation on subsequent cropping, and continued trials on the field performance of runners planted after cold storage.

Fruit and vegetable breeding programmes now form a large part of the total endeavour of the Pomology and Vegetable Crops Departments. Nearly

all of this work is of a long-term nature, not least because of the preliminary studies in genetics and other fields that now are so often essential before the breeder can attempt the further practical improvement of crop varieties. This situation is well illustrated by the present work on raspberry breeding, a considerable portion of which consists of studies on the inheritance of disease resistances and immunities, on techniques of interspecific crossing within *Rubus* and on ways of accelerating the life-cycle of the raspberry plant in order to increase the possible speed of the plant breeder's work. Similar problems are encountered with vegetable crops, as in the work to find a suitable technique for producing F_1 hybrid brussels sprout varieties on a commercial scale. All of these breeding programmes are showing a promising degree of progress, and some, such as that on stringless French Beans, have already reached the stage at which promising stocks are being compared with existing commercial varieties.

Experiments on the control of weeds by chemical herbicides were extended during the year into vegetable crops. Work was started by the Genetics Department to evaluate the performance under glass of a range of tomato varieties, including some new introductions; and another generation of blackberry seedlings bred for thornlessness was planted out for field assessment. An important result of the year's work at the West of Scotland Unit was the selection of a group of promising new strawberry seedlings, varying somewhat in season of ripening, which will now come forward for further intensive trial.

Although they are not invariably mentioned, no annual review of the Institute's work can overlook the part played by those departments whose contribution to the research effort is an indirect one. The Laboratory Service Department was more than usually busy in 1960/61, especially during the move into the new wing, and the demands upon it from other departments for technical constructional work became so numerous that a fairly rigid scheme of priorities had to be imposed. The Farm and Plantations staff, though much hampered by inclement weather, well maintained the outdoor appearance of the Station, and the Glasshouse staff are to be congratulated on an outstanding improvement effected in the upkeep of the amenity grounds in the vicinity of the main building.

STAFF

There were no staff changes in the Scientific class during the year. Three new Assistant (Scientific) appointments were made: Mr. E. D. McCabe to the Laboratory Service Department, Mr. E. B. Paterson to the Genetics Department and Miss E. W. Reid to the Pomology Department.

Miss V. S. C. Jackson resigned from the post of Librarian on taking an appointment in Canada, and was succeeded by Mr. W. Anderson. Miss B. M. Doughty was appointed to the post of Director's Secretary in place of Miss S. G. Rodger, who resigned on marriage.

Seven other resignations have to be recorded on the Experimental Officer and junior staff side. Mr. J. P. Sutherland left the Pomology Department on obtaining an appointment as a horticultural advisory officer at the North of Scotland College of Agriculture. Miss B. M. M. Tulloch was

promoted to fill the vacancy that this created, and Miss E. M. Prain was appointed to succeed Miss Tulloch. Mr. J. A. A. Renwick resigned his post in the Laboratory Service Department on obtaining an appointment in the U.S.A., where he hopes to extend his experience, and was succeeded by Mr. R. MacDonald. Miss H. L. Nicoll (Shorthand Typist) and Miss B. D. Riddoch (Assistant, Physiology) resigned on marriage and were succeeded by Miss H. Moncrieff and Miss A. C. Lindsay, and at the end of the year Miss A. Bulloch (Assistant Experimental Officer, Virology) also left to be married. Miss A. R. C. Sneddon (Assistant, Virology), Miss J. G. Forsyth (Assistant, Laboratory Service) and Mr. R. Stewart (Store-keeper) also resigned and were replaced by Miss W. I. Pattullo, Miss D. McR. Dewar (now transferred to Virology) and Mr. W. Waterston.

Miss F. W. Millar married and became Mrs. Gow; Miss J. A. Weaver married and became Mrs. Myles, and Mr. H. Taylor of the Vegetable Crops Department married Miss M. J. Martin of the same department. All three ladies are continuing in their posts.

VISITS ABROAD

Between May and July Mr. R. M. Lister made a six-week tour of strawberry-growing areas and virus research centres in the U.S.A., in the course of which he surveyed the incidence of diseases attributable to soil-borne viruses and demonstrated techniques of isolation and identification used in the study of these viruses at Mylnefield. The Institute gratefully acknowledges a travel grant of $2,000 generously donated by the Rockefeller Foundation to enable this visit to take place. A grant from the Agricultural Research Council enabled Mr. Lister also to visit strawberry areas in the Netherlands and Germany and to attend the 4th Conference on Potato Virus Diseases at Brunswick in September.

Dr. C. H. Cadman read a paper at the 4th Symposium on Virus Diseases of Fruit Trees in Europe, held at Copenhagen in July. He later visited the Netherlands and attended the 4th Conference on Potato Virus Diseases at Brunswick in September, where he and Mr. Lister gave a joint paper. These visits, too, were made under grants from the Agricultural Research Council.

Other grants from the Council enabled visits to be paid to Europe by Dr. W. R. Jarvis in June and Dr. A. R. Wilson in September. Dr. Jarvis visited centres of research in Belgium and the Netherlands, primarily to obtain information on current research on grey mould diseases of horticultural crops. Dr. Wilson attended the First Triennial Conference of the European Association for Potato Research at Brunswick, where, at the General Meeting, he was re-elected Vice-President of the Association for a further period of three years. On the way to Brunswick, visits were paid to research centres in France, Switzerland and Germany to discuss problems of mutual interest, particularly in the field of grey mould research.

In August, Mr. R. D. Reid and Dr. C. G. Guttridge were invited to read papers at the centenary meeting held at the State Institute of Agronomy at Gembloux, Belgium. Acknowledgment is made of the payment by the State Institute of a proportion of Dr. Guttridge's travel expenses.

Miss W. G. Priestley, when privately in Denmark, paid visits to a number of horticultural research stations and seed firms.

OTHER ACTIVITIES

The year brought an unusually large number of visitors to the Institute. In addition to the distinguished scientists who attended the symposium on soil-borne viruses, overseas visitors were received from Belgium, Canada, France, Germany, Holland, India, Iran, Italy, Malaya, Norway, Peru, South Africa, Switzerland and the U.S.A. An increasing number of growers, both from England and Scotland, are now visiting the two stations of the Institute and are particularly welcome. Two Open Days were held, one in July for fruit-growers, which was moderately attended in the face of poor weather, and a second in October for vegetable-growers. Although the October event, too, was held under rather unfavourable weather conditions, about 40 visitors attended and inspected the vegetable trial plots.

An interesting recent development is the increasing number of requests we are receiving for senior science pupils of secondary schools to visit the Institute. This interest is not confined to schools in the Dundee area. It is difficult to decide how far visits of this kind should be encouraged, but our information is that they have been found useful and are much appreciated. In the absence of an official guide or information officer, the reception of such parties unavoidably makes considerable demands on the research workers' time.

Early in the spring of 1961 the Scottish Branch of the Science Masters' Association held its annual meeting in Dundee and the members paid an afternoon visit to the Institute.

Mr. A. B. Wills, of the Genetics Department, returned to the Institute in August after studying for fifteen months in the Horticultural Department of Rutgers University, New Jersey. It is a pleasure to record that in November the University awarded him its degree of Master of Science, for a thesis presented on the resistance of strawberries to red core infection. The thanks of the Institute are due to all who helped to make Mr. Wills' visit to the U.S.A. both valuable and enjoyable.

Miss N. N. Tun, after working for a year in the Genetics Department as part of her research for the degree of Ph.D. in the University of St Andrews, left to complete her studies with Professor J. H. Burnett, now at King's College, Newcastle. In addition to carrying out her own research studies, Miss Tun gave several valued pieces of help in connection with the cytology of the fruit species now being bred at Mylnefield.

Dr. W. Oleksiak, of the Institute of Pomology, Skierniewice, Poland, came as a British Council Scholar to work for three months in the Virology Department. It was with deep regret that we received news from Poland of the death of Dr. Oleksiak in April, 1961.

Dr. G. M. L. Haskell, personally and on behalf of the Institute, attended a celebration meeting in July to commemorate the Fiftieth Anniversary of the founding of the John Innes Institute. In February, Dr. Haskell was appointed an Honorary Lecturer in the University of St Andrews.

Requests by scientific societies and growers' organizations for lectures by the staff of the Institute were about normal in number. The Director addressed several University Societies and meetings of horticulturists on the general work of the Institute, and he and other members of staff gave broadcasts. Dr. North was invited to read a paper on 'Vegetables for Canning and Quick-freezing' at the National Horticultural Research Conference held in Dublin in December. The number of publications from the Institute, both in the more fundamental and the more applied fields of research, is increasing: lists of current papers appear as usual in the separate departmental reports.

ACKNOWLEDGMENTS

In addition to the acknowledgment of grants for overseas travel referred to in an earlier section, the special thanks of the Institute are due to the Agricultural Research Council for the encouragement and financial support it gave to the Symposium on Soil-borne Viruses. Without the grants provided by the Council, several important members who contributed notably to the success of the Symposium could not have accepted our invitation to attend.

We again received, and very gratefully acknowledge, the gift of a sum of money from Scottish Agricultural Industries Ltd. for use in connection with social amenities for the staff.

It is also a pleasure to acknowledge the many gifts of chemicals, including herbicides, fungicides and growth substances, and also of seeds and plants, received from commercial and industrial firms and other sources for use in experimental work. These items have now become too numerous to list individually, but we gratefully thank all who assisted the work of the Institute in this way.

For co-operation in the assessment of the processing quality of fruits and vegetables we wish to thank the British Food Manufacturing Industries Research Association, Leatherhead; Chivers & Sons Ltd., Montrose; the staff of the Ministry of Agriculture, Fisheries and Food's Research Establishment, Aberdeen; John Morrell & Co. Ltd., Dundee, and Smedley's Ltd., Dundee.

Once again several growers kindly co-operated by providing facilities for field trials. Messrs. W. A. Baxter & Sons Ltd., Fochabers, allowed a trial of chemical weedkillers to be conducted in one of their raspberry plantations near Elgin, Morayshire; land for vegetable trials was provided by Messrs. D. Carmichael (Carluke), J. R. Dale (North Berwick), J. Naismith (Overton), R. L. Scarlett (Inveresk) and J. H. Warnock (Wishaw); and Messrs. Robert Niven & Son, The Sholach, Essendy, Blairgowrie, co-operated with the Mycology Department in work on die-back of raspberries. Our sincere thanks are expressed to each of these growers and also to Messrs. J. & A. Henderson Ltd., Airdrie, who provided both facilities and assistance for the work of the Mycology Department on potato storage.

Advice and assistance were again received from the A.R.C. Unit of Statistics at the University of Aberdeen and from the Statistics Section of

East Malling Research Station. The Pomology Department is particularly indebted to the Aberdeen unit and to the Statistics Department at Rothamsted Experimental Station for the carrying out of several large statistical analyses on the electronic computer at Rothamsted. The Pomology Department also acknowledges the continued help of the Chemistry Department of the Edinburgh School of Agriculture in connection with raspberry manurial experiments at Mylnefield. Finally, we again thank the Chief Surveyor of the Department of Agriculture and Fisheries for Scotland for the reproduction of the Institute's Cropping Record which appears in this Report.

FARM AND PLANTATIONS

L. S. Gray

In marked contrast with 1959, the 1960 season was one of the most adverse hitherto experienced, and almost the only mitigating feature of the whole period now reported upon was the dry, mild weather in February and March of 1961. Despite appalling harvest conditions, however, crop losses were not serious. A reasonably good hay crop was secured, and the sugar beet crop, lifted during one of the few periods of better weather, yielded 14·3 tons per acre, with an average sugar content of 16·14 per cent. Potato harvesting was protracted into November but eventually the whole crop was lifted: and although winter wheat was not sown until the first week of December, it was well grown by March. Grazings were productive and 48 bullocks were fattened and sold during the year.

The weather also provided difficult harvesting conditions for most of the fruit crops, but yields nevertheless were high. The total sales of strawberries, 12 tons, equalled only about three-quarters of the 1959 output, but raspberries gave a record production of 42 tons. Black currants also cropped well: more than 3 tons were produced, mostly from the 4-acre area of young seedlings in the breeding plots. With the increased size of the trees there was again a considerably larger crop of apples, amounting altogether to some 20 tons. Between 5 and 6 tons were sold in bulk to a nearby processor, and carefully graded and regulated supplies of several dessert and culinary varieties were marketed in Dundee. It is of interest that the best prices obtained were for the variety Red Melba and certain other North American apples. Plums also cropped well but were variable in quality. About 2 tons were marketed.

Brussels sprouts were the main vegetable crop: 5½ tons of these were marketed, and also leeks and some other vegetables. After successful preliminary trials (see 1958-59 and 1959-60 Reports), the storage of cabbage in outdoor clamps was undertaken for the first time on a field scale, with results which are described elsewhere (see p. 31).

A good crop of tomatoes (var. Ware Cross) was produced in the glasshouse unit at Carselea.

General estate work included the routine maintenance of fences, windbreaks and shelter belts. The older mixed coniferous and deciduous shelter belts, planted in the period 1953-55, are now providing useful shelter for crops. A group of rose borders was planted in April to face the front of the main building of the Institute, and further sites around the new extension wing were planted later in the year with ornamental trees and shrubs. The earlier plantings in this area have now reached an attractive stage of development.

POMOLOGY

C. A. Wood

Soft fruit crops at Mylnefield in 1960 were again heavy, due undoubtedly in part to the warm and sunny weather of the summer and early autumn of 1959. Raspberry canes had entered the winter sound and well matured, and their lateral growth in the spring was excellent, with very few dead or backward canes present. The picking periods for strawberries (20 June-20 July), black currants (5 July-8 August) and raspberries (4 July-17 August) differed little from those of 1959: strawberries finished earlier and black currants slightly later. It should be remembered that these periods, as reported here annually, cover a wide range of varieties of the three fruits.

The soft fruit season was made difficult by wet weather in July and early August (see p. 71). Apples, however, benefited from the adequate spring rainfall as well as from the previous year's weather and gave a very heavy crop, which was of much better storage quality than the 1959 crop. Pears and plums also gave their best yields to date. More wet weather in October, followed by early frosts, seriously delayed plantation work at the end of the year.

RASPBERRY BREEDING

The most important seedling material under observation in 1960 consisted of families produced in 1958 by sib-crossing selections chosen for good fruit quality. This material fruited for the first time, and several seedlings appeared to have retained the good fruit texture of their parents while showing improvement in fruit size and in the ability of the berries to withstand adverse weather.

Also fruiting for the first time was a progeny of 114 seedlings raised from seed harvested from a mutant of Malling Jewel growing in isolation. This mutant is characterized by a considerable enlargement of all parts of the fruiting laterals, including the flowers and fruit. In addition to normal forms and forms similar to the parental mutant, the progeny included more extreme types with malformed laterals, and frequently with sterile flowers. Classification of the seedlings showed normal, mutant and extreme forms in the ratio of 40: 56: 18, which does not depart significantly from the ratio to be expected if the mutation were caused by a change in a major gene from the homozygous to the heterozygous state, and if the latter were intermediate in expression.

As part of the programme of inbreeding to produce lines breeding true for good fruit qualities, some of the best inbred seedlings derived from crosses of Malling Jewel with Burnetholm Seedling and Baumforth's Seedling B were self-pollinated and sib-crossed to give the second inbred generation.

Genetics of Resistance to Viruses and Fungal Pathogens

Studies on the inheritance of immunity to three soil-borne viruses which affect the raspberry were continued as described in the last Report.

In the field experiment planted in 1959 to compare the rates of spread of veinbanding disease (caused by aphid-borne viruses) in the resistant varieties Norfolk Giant and Malling Exploit and seedling derivatives of them, very little spread of the disease has so far occurred. The numbers of aphids (*Amphorophora rubi*) carried by the different seedling clones in 1960 varied considerably, and on 2 out of 17 derivatives of Norfolk Giant the populations did not significantly exceed that on Malling Landmark, which carries a major gene (A_1) for resistance to this aphid. It seems, therefore, that the total resistance to infection contributed by Norfolk Giant to its progeny includes both virus resistance and resistance to colonization by this aphid vector.

In order to study the effect of cane morphology on the incidence of fungal diseases of raspberry canes, families segregating for the gene differences *H*:*h* (hairy: sub-glabrous surfaces), *B*:*b* (waxy: non-waxy surfaces) and *S*:*s* (spiny: spine-free surfaces) were scored for frequency of symptoms of spur blight (*Didymella applanata*), cane spot (*Elsinoe veneta*) and *Botrytis cinerea*. The incidence of spur blight and of *B. cinerea* varied little between families, but there appeared to be a strong tendency for seedlings to escape infection if they were of phenotypes associated with the genes *H*, *b* or *s*. Some families showed a very high resistance to cane spot, and resistance in inbred families was closely correlated with that of the parents. In three susceptible families the incidence of the disease was slightly greater on the hairy than on the sub-glabrous seedlings, but data on the effects of the other gene differences were inconclusive. Seedlings homozygous for the gene *t* (green spines and yellow fruits) were less severely affected by any of the diseases than those carrying the dominant gene *T* (red or tinged spines and red fruits). The gene *t* is concerned in the production of certain flavone pigments which are known to have fungistatic properties.

These results suggest that escape from infection by *D. applanata* and *B. cinerea* can best be obtained by selecting seedlings whose canes are spine-free and either hairy or devoid of a waxy bloom; but a high level of resistance to cane spot is available which is not associated with these features of cane morphology.

Tetraploid Raspberries

Comparative observations on tetraploid forms of Malling Jewel, Malling Exploit and the East Malling seedling 69/139 showed that the percentage of abortive pollen varied considerably with variety and with temperature level. All three forms produced lower percentages of abortive pollen when grown in a very warm glasshouse (mean temperature about 75°F.) than when grown in a moderately warm one (mean temperature about 60°F.). The percentages were highest in Malling Jewel (15-30%), intermediate in Malling Exploit (10-25%) and lowest in seedling 69/139 (4-9%). The quantity of seed set, however, was also highest in Malling Jewel and lowest in 69/139, and therefore inversely related to pollen fertility. Seed-set was slightly reduced at the higher temperature, but was increased slightly in 69/139 and more substantially in Malling Jewel by substituting the pollen of the diploid form for that of the tetraploid. These results suggest that differences in the capacity of tetraploids

to set seed are determined by genetic factors others than those which determine the viability of their pollen. (D. L. Jennings, B. Tulloch.)

'Crumbly Fruit' in Raspberries

A condition described as 'crumbly fruit' has been known for some years in the raspberry variety Malling Promise, and isolated cases have been noted also in Norfolk Giant and Malling Jewel. The vegetative growth of affected plants is normal, but the number of drupelets set on each fruit is so reduced that the berries are small, misshapen and excessively crumbly. Affected plants were thought to have arisen as a result of somatic mutations affecting fertility, and, in the case of Malling Promise, to have been multiplied vegetatively in nursery stock before diagnosis of the condition in the fruit.

This hypothesis is now supported by cytological and genetical observations. In the crumbly form of Malling Jewel meiosis in the pollen mother-cells is apparently normal, but abnormal subsequent development results in the production of a high percentage of abortive pollen. Inbred families raised from Malling Jewel, from one of its parents (Preussen) and from 8 of 12 F_1 derivatives of it each gave a 3:1 segregation ratio for normal:crumbly-fruited seedlings, and a high proportion of crumbly forms also occurred in a family raised from open-pollinated seed of an affected plant. This suggests that Malling Jewel is heterozygous for a recessive gene controlling gamete development, and that its crumbly-fruited condition arose through a somatic mutation which made this gene homozygous. A different situation, caused probably by a chromosome mutation, appears to explain the crumbly condition in Norfolk Giant. Here a lagging chromosome was observed in affected plants at meiosis, and two families raised from normal and crumbly-fruited parents contained normal seedlings only, apart from a high proportion of apparently polyploid seedlings in the second family. These probably resulted from the fertilization of unreduced egg cells. The investigation of crumbly-fruitedness in Malling Promise is at an earlier stage, but there are indications that it may originate in a similar way to the condition in Norfolk Giant. (D. L. Jennings, N. N. Tun.)

BLACK CURRANT BREEDING

The promise shown in 1959 by certain intervarietal black currant crosses involving the parent varieties Brödtorp and Silvergieter's Black was well maintained in 1960, when the families concerned fruited on a much larger scale. Selections were made from 22 of the 38 families planted in 1958 and 1959, but nearly one-third of the total selections were from the crosses Brödtorp × Silvergieter's Black and Baldwin × Brödtorp. The remainder included some from families raised by selfing Brödtorp and Silvergieter's Black.

Twelve more families from seed which germinated in 1959, comprising about 600 seedlings, were planted out in the spring. These families include eight crosses between species within the *Eucoreosma* sub-genus of *Ribes* and three more selfs of black currant varieties. A programme of selfing and back-crossing was begun with the more promising of the selections made in 1959. (M. M. Anderson, W. Fordyce.)

One of two hybrids between Baldwin black currant and an unidentified species of *Ribes* (not *R. maximowiczii*, as stated in the last Report), which were treated with colchicine in 1960, was found to be consistently tetraploid in chromosome number. (N. N. Tun.)

THE CULTIVATION OF RASPBERRIES

Experiments planted in 1952 and 1954

Two more experiments of this series, one comparing the 'single' and 'double' planting of raspberry canes and the other comparing systems of training for fruiting canes, were terminated during the year. Each in its final season gave results consistent with those of the two preceding years.

In the experiment planted in 1954 to compare the performance of stooled raspberry rows with that of rows grown as continuous 'hedges' of non-stooled plants, the differences of yield between the two systems in three contrasting varieties were again small but slightly in favour of the stool system. This confirmed the results of most previous years. Because this experiment may be affected by age and seasonal conditions, however, it is being continued for a further period.

Experiments planted since 1956

In the main experiment of this later series, three levels of nitrogen (0, 40 and 80 lb. N per acre applied annually as ammonium sulphate), three of phosphorus (0, 33 and 66 lb. P_2O_5 per acre applied annually as superphosphate), three of potassium (0, 80 and 160 lb. K_2O per acre applied annually as potassium sulphate) and three of farmyard manure (0, 15 and 30 tons per acre applied biennially) are being tested in factorial combination with the raspberry varieties Malling Exploit, Lloyd George and Norfolk Giant. The design is a one-third replicate of 3^5 in 9 blocks of 9 plots each, the unit plots consisting of three rows 10 yd. long and 6 ft. apart. The main field records taken are of numbers and heights of new stool canes in autumn and winter and of crop yields in summer. Foliar analyses are made on leaf samples taken each July and soil analyses are made annually in late winter, shortly before re-application of the treatments.

This experiment is now entering its fifth growing season, and a statistical analysis of the accumulated records will shortly be made. The main effect so far, however, has clearly been that of nitrogen. Increases of nitrogen level have consistently and substantially increased cane populations and fruit yields per acre, and in the seasons prior to 1960, when cane numbers were smaller, they also increased the yields per cane. These effects have been clearest in Norfolk Giant and least marked in Lloyd George: in the former, the increase of annual nitrogen supply from nil to 80 lb. per acre increased the total fruit yield in the years 1958-60 by about 50 per cent. In the light of these results, changes have recently been made in the standard programme of manuring used for raspberries at Mylnefield.

The last Report described an experiment to compare six different systems of soil management for raspberry plantations—a permanent straw mulch, a closely-mown cover crop and four variants of the conventional system of clean cultivation. Malling Exploit was chosen for this experiment as being a

variety fairly prolific in cane production and of spreading growth habit, and therefore not a particularly easy one in which to conduct inter-row cultivations and mowing. Here again the accumulated records of four seasons await full analysis, but the results leave little doubt that the four clean cultivation systems (which differ mainly in the depth of hand and mechanical cultivation applied) are all satisfactory if practised with care and skill. Under the cover crop (mainly of timothy and white clover) the cane growth has been of good quality and more upright in habit than under clean cultivation, and this method may have much to commend it where there is adequate rainfall. By contrast, the straw mulch method showed to advantage in the dry season of 1959: weeds and raspberry suckers which grow through the straw have been controlled to some extent by the use of contact herbicides.

In the experiment planted in spring 1957 to compare the performance of virus-free stocks of Malling Jewel and Lloyd George with that of older, mildly virus-affected stocks, all four stocks cropped in 1960 at between 3 and 4 tons per acre. In Malling Jewel the originally virus-free stock again outyielded the lower grade material—by about 14%—but the yields of the two Lloyd George stocks were nearly equal. Sample tests have shown that most, if not all, of the originally healthy stools in this experiment are now to some extent virus infected, but the general growth of all the stocks remains vigorous.

Two experiments planted in 1957/58, one to compare the performance of canes lifted from a nursery at various dates in winter and planted in spring, and the other the performance of autumn- and spring-planted canes, were converted to new uses and in 1960 cropped for the first time under the new treatments. They now compare, respectively, three frequencies of fruit picking and four methods of treating the top portions of the new canes after these have been tied-in in winter. Both are planted with Malling Exploit and Lloyd George. (C. A. Wood, M. M. Anderson.)

WEED CONTROL

Raspberries

Field experiments were continued on the use of long-persistent residual herbicides for the control of annual weeds in raspberry fruiting plantations. In a trial planted in 1959, in which the yearly chemical treatments in terms of active ingredients per acre are simazine (2·5 lb.), monuron (3·5 lb.) and mixtures of 2,4-DES (4·6 lb.) with propham (4·0 lb.) or with fenuron (0·5 lb.), no unfavourable effects on the crop were noted and the yields under these four treatments did not differ significantly. The mechanically cultivated control plots, however, gave a much lower yield, as a result of weed growth having been allowed to develop for too long in the spring of 1959. In 1960 each treatment of the experiment was managed as a separate entity, receiving hand cultivations along the rows whenever necessary, and the control plots showed an excellent recovery in their new cane growth. The simazine- and monuron-treated plots, after being sprayed on 1 April, remained almost free from annual weeds for a year, while the mixtures containing 2,4-DES gave adequate weed control only until mid-May, when hoeing became necessary. The plots of all treatments were twice cleaned along the rows with Dutch hoes, primarily for sucker removal, and shallow rotary cultivation was given

between the rows throughout the experiment whenever the weediest plots required it. This rotavation had no serious effect on the efficiency of weed control on the simazine and monuron plots.

Chemical treatments were also re-applied to an older experiment mentioned in the last Report, and in the spring a third replicated experiment was planted. Commencing in 1961, the annual treatments in this will be simazine (1·5 lb.), monuron (3·0 lb.), diuron (3·0 lb.) and an alternation of simazine (1·5 lb.) and monuron (3·0 lb.), again together with a mechanically cleaned control treatment.

Samples of fruit from plots treated with simazine, monuron and mixtures of 2,4-DES and fenuron, 2,4-DES and propham, propham and fenuron and TCA and dinoseb amine were supplied to the British Food Manufacturing Industries Research Association, Leatherhead, for tests to detect off-flavours in jam.

The annual treatments under test in a Malling Exploit cane nursery (see previous Reports) were applied for the third and final year. Plots treated in early spring with monuron (3 lb./acre) and simazine (2 and 3 lb./acre) again gave the best yields of cane both in numbers and quality. Bio-assay tests on soil samples from these plots some twenty weeks after the second (1959) spraying indicated that active residues were largely confined to the surface inch of soil.

A first attempt was made in July to control by means of a contact herbicide the unwanted sucker canes which grow along and between the rows of raspberry fruiting plantations. These must at present be removed physically even when weeds have been controlled chemically. A mixture of 2 lb. diquat and 5 gal. diesel oil in 100 gal. water per acre, with sufficient wetter to emulsify the diesel oil during the spraying period, killed young suckers of Norfolk Giant (up to about 18 in. high) to ground level, destroying at the same time a dense covering of annual weeds.

In a trial near Elgin, Morayshire, dalapon at 8 and 16 lb./acre was applied at monthly intervals from late March to late November (except in June) to a Malling Enterprise plantation severely infested with couch grass. Normal seasonal cultivations were also given, and simazine at 2 lb./acre was applied to one-half of the total experimental area in March. The combined dalapon and simazine applications in March killed most of the established weed growth and prevented further growth of couch grass and other perennial weeds until June. The later dalapon sprays, however, were less effective against couch grass; and the May application caused stunting of the new raspberry cane growth and the July application a severe necrosis and yellowing of the upper foliage of the canes. This damage appeared to be associated with the occurrence of heavy rainfall soon after the sprays were applied.

Tests with raspberry root cuttings grown in soil mixed with simazine failed to reveal any difference between Malling Jewel and Lloyd George in susceptibility to this herbicide.

Strawberries

Part of a sixth-year plantation of Talisman was used to test five herbicide treatments applied in early March, after the rows had been cleaned by hoeing.

The treatments, again in terms of active ingredients per acre, were monuron (3 lb.), simazine (2 lb.), atrazine (2 lb.), diuron (3 lb.) and a mixture of chlorpropham (2·5 lb.) with monuron (1·0 lb.). A hand-cleaned control treatment was also included. The simazine and atrazine applications gave excellent weed control without visible damage to the strawberries or any reduction of yield, but the monuron and monuron/chlorpropham treatments respectively caused chlorosis and stunting of the strawberry plants, and both reduced fruit yields significantly. The monuron and diuron treatments failed to give an adequate control of weeds, especially *Senecio vulgaris* and *Veronica spp.*

Potatoes

Flavour tests were made by the British Food Manufacturing Industries Research Association and by the Ministry of Agriculture, Fisheries and Food on tuber samples from the 1959 potato herbicide trial (see 1959-60 Report). The results were inconclusive, but indicated that no easily detectable off-flavours had been caused by the treatments applied.

A smaller replicated trial was planted in 1960 with the variety Majestic. The chemical treatments in rates per acre were trietazine (2 lb.), atrazine (2 lb.) and a mixture of dinoseb amine (6 lb.) with dalapon (2·5 lb.), all applied shortly before crop emergence, and both hand and mechanically cultivated treatments were included as controls. The dinoseb/dalapon treatment kept the plots free from annual weeds until lifting time, and the yields from this and the two cultivated treatments were very similar. Weed control was less complete under the trietazine and atrazine treatments, and this may have caused slight reductions of yield, although the differences from the control yields were not significant. Tuber samples were again submitted for flavour tests.

Sugar Beet

Two small demonstration trials—at Pittenweem, Fife, and at Mylnefield—were established to test the mixture of endothal and propham developed at the Norfolk Agricultural Station, Sprowston, Norwich, for weed control in sugar beet. The mixture used per acre was 6 lb. endothal (sodium salt) and 3·6 lb. propham. This was applied approximately 6 days before the emergence of the beet seedlings. Weed control at both sites was excellent, and no crop injury was observed.

Brussels Sprouts

Sodium monochloracetate was applied at 20 lb. per acre to a seed-bed of Cambridge No. 1 brussels sprout at the second true leaf stage, when the ground was heavily infested with annual weeds. The crop seedlings were slightly scorched and several annual weed species severely scorched or killed, but the treatment was ineffective against *Poa annua*, *Chenopodium album* and *Fumaria officinalis.*

Soil Persistence of Residual Herbicides

Following the successful use of a ryegrass bio-assay method for the detection of persistent herbicide residues in soil, a long-term experiment has recently been established in open ground to investigate the movement and rates of disappearance of certain herbicides of the residual type.

Weed Seed Populations in Soil

Work recently started will attempt to detect changes that may occur in the numbers of weed seeds present in the upper layers of soil of one of the existing long-term raspberry herbicide experiments. (R. J. Stephens, J. P. Sutherland.)

STRAWBERRY INVESTIGATIONS

The experiments conducted in 1958-59 on the response of Talisman and Redgauntlet strawberries to post-harvest defoliation were repeated on the same plots in 1959-60. The plots to be defoliated were mown on 5, 15 and 25 August, 1959, and dressings of sulphate of potash and sulphate of ammonia were applied as described in the last Report.

In comparison with 1959, inflorescence numbers in 1960 were higher on the mown and lower on the unmown plants. Even the plants mown latest carried more inflorescences than the unmown controls and slightly exceeded them in fruit yield. On the plants mown earliest the numbers of inflorescences were increased by 122% and 61% in Talisman and Redgauntlet respectively, and the corresponding figures for increased yields of fruit were 90% and 22%.

Nitrogen treatments again depressed the yield of defoliated plants, the largest reductions occurring on Redgauntlet plots which had received nitrogen both in autumn and spring. The only plants to show an apparent increase of yield from nitrogen treatment were the unmown Redgauntlet plots which had received nitrogen in autumn only.

Post-harvest defoliation was also applied in autumn 1959 to the eight varieties in a Scottish Fruit Trials strawberry trial planted in spring 1958. The four unit plots of each variety were divided into half-plots of 24 plants each, and on 7 August one half-plot of each pair was defoliated. Except in the variety Senga Sengana the mown plots in spring 1960 carried the larger numbers of inflorescences, the increases ranging from 4·2% in Senga 54 to more than sevenfold in Talisman and Cambridge Rearguard. The mown plots of the last two varieties gave crop increases equivalent to about 7 and 5 tons per acre respectively, and there were increases of about $2\frac{1}{2}$ tons in Redgauntlet and Merton Princess. Cambridge Vigour and Royal Sovereign responded least to the treatment. The crop of Senga Sengana was increased by more than a ton per acre even though no increase was recorded in the number of inflorescences in this variety. (M. M. Anderson.)

Trials of new strawberry seedling selections were continued in co-operation with the West of Scotland Unit. (C. A. Wood, M. M. Anderson.)

APPLE VARIETY-ROOTSTOCK TRIALS

Growth and cropping in these trials was generally good except in two trials of dessert apples on medium rootstocks, where some varieties—particularly Laxton's Superb and to a lesser extent Worcester Pearmain—showed poor growth and fruit size as a result, probably, of the grassing-down in 1959 of strips of ground previously maintained in cultivation along the lines of trees. The foliage colour in these and other grassed-down trials of the series indicated nitrogen deficiency, and additional dressings of nitrogenous fertilizers were therefore given during the winter.

In the trial of dessert varieties as bush trees on the dwarfing and semi-dwarfing rootstocks M.IX and M.VII, all eight varieties cropped more heavily than in 1959, and the trees on M.VII for the first time outyielded those on M.IX. This trial was grassed down in the summer, a step which probably contributed to the improved storage quality of some varieties, especially Cox's Orange Pippin and Ribston Pippin. The results with Cox were the best so far obtained, and good quality fruit of it was marketed locally for the first time. One reason for grassing-down this trial is to see if the change checks the spread of stem canker. The disease is prevalent only in the area of this one trial, where about a quarter of the trees have been attacked and several killed. The only variety not yet affected is Winston, while the worst-affected have been Red Melba and Wagener. Lord Lambourne and Miller's Seedling have been attacked slightly and Tydeman's Early Worcester, Merton Worcester, Cox's Orange Pippin and Ribston Pippin more severely.

The trials of dwarf pyramid trees planted in 1959 made excellent growth. Of the two main varieties included, Sunset, as expected, has so far made more attractive trees than Worcester Pearmain, and it gave a light crop in 1960. The alternative pruning methods to be compared in these trials—ordinary summer pruning and 'festooning'—were first applied during the year. (W. Fordyce.)

OTHER VARIETY TRIALS

Apples

As expected, the favourable conditions during blossoming, following after the warm, sunny season of 1959, led to a heavy fruit set throughout the older apple variety trials, and thinning was for the first time a serious commitment. Many of the trees in these trials are near to full bearing age.

Notwithstanding the wet summer, the fruit colour of most varieties in 1960 was again very good, and this was once more particularly true of some of the North American dessert apples. Nitrogen deficiency symptoms in the foliage, which were very marked in the dry season of 1959, did not reappear in 1960 following the higher rainfall and the application in early spring of urea sprays.

Of the total of more than 800 trees in the Apple Variety Collection, 668 cropped, 212 of them for the first time. Among the latter were several commercially important American and Canadian varieties, including some of fairly recent origin. In the 1953 'elimination' trial of modern and commercial apples, 97 of the 103 varieties cropped. During the winter the trees on rootstocks M.IV and M.VII in this trial were removed, leaving those on M.I and M.II spaced at 24 ft. × 15 ft. This thinning will ease cultural work, particularly grass mowing, and allow a more satisfactory development of the remaining trees.

The storage of midseason and late varieties in a cool room at ground level was much more successful than in previous years. Cold nights during November, and the use of an intake fan to draw night air into the store, helped considerably, and successful use was made of polythene bags for storing the main supplies of Cox's Orange Pippin, Laxton's Superb and Ribston Pippin and many small samples from the variety collection.

Thirteen dessert and seven culinary varieties were graded and packed for the local wholesale market. The best prices obtained were for the Canadian varieties Red Melba, Lawfam, Hume, Lobo and Melba, with Cox's Orange Pippin, Lord Lambourne and Beauty of Bath leading among English desserts. Bramley's Seedling sold best among culinary apples and Worcester Pearmain (although a very good sample) poorest among desserts. (W. Fordyce.)

Black Currants

In the 1955/56 black currant variety and pruning trial, cropping for its fourth season, the heaviest yielding variety was Amos Black, followed by Brödtorp and Wallace Seedling. In seven of the eight varieties the bushes pruned in late summer slightly outyielded those pruned in winter, a reversal of earlier trends. This trial was terminated in the autumn. (M. M. Anderson.)

Red Currants

In one of the two red currant trials previously reported, containing five varieties, Earliest of Fourlands again gave the highest yield, followed by the late variety Ayrshire Queen. Wind damage in the previous winter reduced the cropping of Laxton's No. 1, Jonkheer van Tets and Red Lake. In the trial of 15 varieties the first three in order of yield were New Red Dutch, Red Dutch and Earliest of Fourlands. Both trials as a whole cropped heavily. (M. M. Anderson.)

Plums

The 1953 'elimination' trial of plum varieties gave its largest crop to date. Forty-four varieties cropped, including for the first time Teme Cross and Wye Cross. The heaviest yields were from Warwickshire Drooper, Belle de Louvain, Blue Rock, Cox's Emperor (which again showed serious splitting) and Laxton's Cropper. The entire crop found a ready market but the best price obtained was for Laxton's Bountiful. Of the gage plums, Apricot Gage and Denniston's Superb were best in yield and of reasonably good quality, while Jefferson's Gage, Brahay's Green Gage and Bryanston Gage cropped well but showed some cracking. Among other dessert plums, Victoria and Avon Cross gave their first substantial crops. Wyedale and Severn Cross again ripened much too late in the autumn. (W. Fordyce.)

Pears and Cherries

The season was also the best so far for pears: 64 varieties in the collection cropped, 45 of them for the first time. Louise Bonne of Jersey, Laxton's Superb, Conference and Bristol Cross, varieties which have been among the best in past years, again cropped and ripened well, with Bristol Cross leading in yield. Beurré Giffard, Beurré d'Amanlis and Fondante d'Automne were also good in yield and quality.

The cherries of the 1955 trial continued to make good growth, but although blossom was plentiful there was a poor fruit set. Birds were again troublesome. No fruit was recorded, but the varieties which set most fruit were Merton Heart, Géant de Hedelfingen and Early Rivers. (W. Fordyce.)

Scottish Regional Fruit Trials

These are variety trials conducted at the three Scottish Agricultural Colleges and at Mylnefield under the sponsorship of the Scottish Fruit Trials

Committee. New plantings in spring 1960 consisted of a raspberry trial of seven varieties, all planted as virus-free stocks, and a health demonstration plot of raspberries which is intended to illustrate the comparative performance of different grades of certified nursery stock.

An older raspberry trial, planted in 1952 and since discontinued at the three College centres, cropped more heavily at Mylnefield in 1960 than in any previous year. Malling Promise and Malling Jewel cropped at rates exceeding $6\frac{3}{4}$ tons per acre, and the remaining varieties—Malling Exploit, Malling Enterprise, Lloyd George and Norfolk Giant—at rates exceeding 5 tons. These results support the view that the reduced productivity of this trial at all the four stations in the years 1955-1958 was due not to virus infection but to a succession of unfavourable seasons, in which losses were caused mainly by either drought, frost or severe outbreaks of grey mould disease. The Mylnefield trial will be retained for the further study of annual fluctuations in plantation performance: the unit plots have now been halved to receive high and low nitrogen treatments. A final summary of the results of the earlier raspberry and black currant trials of this series was published during the year.*

All the plots of the 1958 strawberry trial were halved in summer 1959 to accommodate a post-harvest defoliation treatment (see p. 21). The yields from the unmown half-plots of four of the varieties in 1960 were again very high, ranging from between 6 and 8 tons per acre for Merton Princess and Senga 54 to between 8 and $9\frac{1}{2}$ tons for Cambridge Vigour and Senga Sengana. Royal Sovereign and Redgauntlet cropped at about 4 tons and Talisman and Cambridge Rearguard at less than 30 cwt. It was the last three of these four varieties that showed the most spectacular increases of yield as a result of defoliation.

In the 1954 trial of plums, yields were recorded on 26 varieties on Common Plum rootstock (6 for the first time) and on 19 varieties on Myrobolan B (12 for the first time). The most productive varieties in each case were Laxton's Cropper and Cox's Emperor, but the latter showed severe cracking of the fruit. Merton Blue on Common Plum and Warwickshire Drooper on Myrobolan B gave good crops of sound fruit, and among the gages Denniston's Superb was of very good quality. Six more trees in this trial died from bacterial canker disease. (M. M. Anderson, W. Fordyce.)

MISCELLANEOUS

Previous Reports have noted the progress of work conducted at Mylnefield by staff of the Edinburgh and East of Scotland College of Agriculture and the Department of Bacteriology, University of Aberdeen, in co-operation with the Pomology and Mycology Departments of the Institute, on the use of paints and sprays for the protection of plum tree stems from bacterial canker disease infection. It was reported last year that two-year-old trees of the variety Victoria had been transplanted into a field experiment. The main feature in 1960 was the large number of deaths which occurred among these trees in the spring, shortly after planting out. Many of the losses were

*Scottish Fruit Trials Committee Leaflet No. 2, published by the Scottish Agricultural Colleges and the Scottish Horticultural Research Institute.

associated with stem cankers which must have resulted from infection in the nursery. The experiment is being continued, together with further work to investigate possible modes of entry of the disease organism into the stems of young trees.

PUBLICATIONS

Research Papers

Jennings, D. L. (1961). Mutation for larger fruit in the raspberry. *Nature, Lond.*, **191**, 302-3.
(A mutant form found in the raspberry variety Malling Jewel has unusually long and thick fruiting laterals and pedicels, enlarged floral parts and an enlarged receptacle which carries more drupelets than in a normal fruit of the variety. The drupelets are larger individually, contain larger seeds, and ripen about two weeks later than in the normal form. A more extreme form occurred when this mutant was inbred. Study of an inbred family suggests that the mutation was caused by a change in a major gene from the homozygous to the heterozygous state, and that the latter is intermediate in expression. It appears that the change affects the development of the axillary meristems, causing an enlargement of all the tissues derived from them. The new gene is valuable to the plant breeder, but it will be necessary to correct some of the undesirable features associated with it, such as the larger seed, by applying selection to the minor genes that govern them.)

(Guttridge, C. G.,) Anderson, M. M., (Thompson, P. A.,) and Wood, C. A. (1961). Post-harvest defoliation of strawberry plantations. *J. hort. Sci.*, **36**, 93-101.
(This paper is summarized on page 45.)

Sutherland, J. P. (1961). Further preliminary trials of chemical weedkillers in raspberries and strawberries. *Proc. 5th Brit. Weed Control Conf.*, 1960, **1**, 351-6.
[This paper reports preliminary, short-term trials on the control of annual weeds in established raspberries and strawberries, the control of *Agropyron repens* in raspberries and the effect of spraying a prepared soil surface with herbicides two days before planting strawberries. Simazine (6 lb./ac.) and atrazine (2 and 4 lb./ac.), applied after a thorough cleaning of the ground in spring, effectively prevented the development of annual weeds in established plantations without causing any observed crop injury. Dalapon (8·5 lb./ac.), applied in March, gave useful results against a heavy infestation of *A. repens* in raspberries but caused some loss of green colour in the new canes. Amitrol (5 lb./ac.), also applied in March, injured raspberry growth severely. Strawberries (var. Redgauntlet) died out completely when planted by trowel on plots which had been sprayed two days beforehand with simazine (2·0 lb./ac.), atrazine (4 lb./ac.), monuron (3 lb./ac.), diuron (4 lb./ac.) or fenuron (0·5 lb./ac.).]

Sutherland, J. P. (1961). Chemical control of overwintered annual weeds in a raspberry plantation. *Hort. Res.*, **1**. (In press.)
(Herbicides were applied to the overwintered annual weed flora present in a 7-year-old raspberry plantation (vars. Malling Promise and Lloyd George) on dates in February, March and May, 1959. There had been no cultivations since the previous summer and none were given after the treatments. Of 21 treatments tested, only three—2 lb./ac. simazine, 4 lb./ac. monuron and a mixture of 3 gal./ac. phenols with 4·05 lb./ac. fenuron—destroyed the existing weed growth and gave adequate weed control for six months without apparent crop injury. Other treatments which controlled or checked the existing weeds either did so at the expense of injury to the crop or showed no residual activity against germinating seedling weeds.)

Sutherland, J. P., and Stephens, R. J. (1961). Effects of some chemical weedkillers on a raspberry cane nursery: a progress report. *Proc. 5th Brit. Weed Control Conf.*, 1960, **2**, 381-5.
(Monuron, simazine and a mixture of 2,4-DES with propham were applied annually in spring to plots of a cane nursery (var. Malling Exploit) planted in spring 1958. No physical cultivation was necessary for three years on plots receiving treatments of

simazine at 2 lb. or 3 lb./ac., and very little on plots receiving monuron at 3 lb. Monuron and simazine at lower rates, and the mixture of 2,4-DES (3·6 lb.) and propham (5·0 lb.), did not eliminate the need for cultivations. Higher yields of cane, of superior quality, were harvested from the plots on which herbicides effectively replaced cultivations.)

WOOD, C. A., ANDERSON, M. M., (and FREEMAN, G. H.) (1961). Studies on the cultivation of raspberries. I. Effects of planting distances and of the winter tipping of canes. *Hort. Res.*, **1**. (In press.)

(This paper reports in full the first of a series of investigations into ways in which variations of cultural practice affect the performance of raspberry plantations. Distances between rows of 5½, 7 and 8½ feet, spacings between stools within the rows of 2, 2½ and 3 feet, and heights of winter tipping of the canes of generally 4, 4½ and 5 feet, were tested in factorial combination with the varieties Malling Promise, Lloyd George and Norfolk Giant in a 7-year experiment. Increase either of inter-row distance or of stool spacing produced an improvement in performance per stool, because of the growth or survival of more canes per stool and a higher fruit yield per cane, but this failed to balance the reduction in cane population per unit area caused by the wider separation of the stools. Extension of planting distances therefore led to lower yields per acre. The changes in inter-row distance had a greater effect on yield per acre than the changes in stool spacing. Increase of tipping height within the range of heights tested produced large increases of yield. Harder (i.e., lower) tipping of the canes slightly delayed ripening.

The productivity of raspberries planted at practicable distances and maintained as permanent stools is approximately proportional to the number of fruiting canes present. The varieties used in this experiment were very similar in their reactions to the cultural treatments tested, although some minor interactions were recorded. Close planting resulted in some years in greater losses of canes and buds associated with infections by the fungi *Botrytis cinerea* and *Didymella applanata*.)

WOOD, C. A., SUTHERLAND, J. P., and STEPHENS, R. J. (1961). Trials of chemical weedkillers in potatoes. *Proc. 5th Brit. Weed Control Conf.*, 1960, **1**, 59-64.

(Trials of weedkillers in potato crops have been in progress at Mylnefield since 1959. The general aim is to eliminate post-planting cultivations where these are applied solely for the purpose of weed control. Dinoseb amine, applied at 6 lb./ac. to the ridged drills shortly before emergence of the crop, successfully replaced cultivations for this purpose in 1959 and 1960 and caused no reductions in yield. Simazine and other residual herbicides of low solubility gave disappointing results, possibly because dry conditions followed their application.)

WOOD, C. A., SUTHERLAND, J. P., and STEPHENS, R. J. (1961). Effects of the use of herbicides on the growth, cropping and weed flora of raspberry plantations: a progress report. *Proc. 5th Brit. Weed Control Conf.*, 1960, **2**, 373-9.

(Preliminary trials of herbicides in soft fruit crops at Mylnefield are followed by tests of the more promising materials in longer-term trials, in which the growth and yield of the crops can be recorded for a period of years and some assessment can be made of possible effects on fruit quality. Two such trials with raspberries are now in progress. In one, the herbicides in annual use are mixtures of propham+2,4-DES, propham+fenuron, fenuron+2,4-DES and TCA+dinoseb; and in the other, simazine, monuron and mixtures of 2,4-DES with propham and with fenuron. This paper reports the results of these trials for three and two years respectively.)

GENERAL PAPERS

FORDYCE, W. (1961). Apples for Scotland: Varieties and Prospects. *Gdnrs' Chron.*, **149**, 50. (21 January.)

(GUTTRIDGE, C. G., and) WOOD, C. A. (1961). Defoliation of Strawberry Plants. *Scot. Agric.*, **41**, 39-42.

JENNINGS, D. L. (1961). Raspberry Varieties of the Future. *Gdnrs' Chron.*, **149**, 292. (8 April.)

STEPHENS, R. J. (1961). The Control of Perennial Weeds. *Gdnrs' Chron.*, **149**, 208. (11 March.)

STEPHENS, R. J. (1961). Ousting Perennial Weeds in Fruit Crops. *Smallholder*, 2640, 27. (4 March.)

SUTHERLAND, J. P. (1960). Chemical Weed Control in Fruit Crops. *J. R. Caledonian hort. Soc.*, 1960, 38.

WOOD, C. A. (1960). Soft Fruit in Scotland: the Scene is Changing. *Smallholder*, 2595, 21. (11 June.)

WOOD, C. A. (1960). Training Systems for Raspberries. *Smallholder*, 2618, 21. (19 November.)

WOOD, C. A. (1961). Spring Cultivations for Raspberries. *Smallholder*, 2635, 25. (18 March.)

VEGETABLE CROPS

C. North

VARIETY TRIALS

French Beans

During the wet weather in late summer a serious outbreak of anthracnose (caused by the gamma strain of *Colletotrichum lindemuthianum*—see p. 64) affected most of the varieties under trial. No lesions developed on the pods of Refugee or of Slavia and relatively few on those of Double Princess, Prelude, Contender or Konserva II, but the pods of Top Crop, Parathan Viaz and Korischnevaja were badly affected. However, the attack occurred late in the season and caused very little reduction of yield in any of the varieties. Masterpiece gave the highest yield and Record and Prelude were nearly as productive. The new Dutch variety Prelude has given very promising results during the two seasons in which it has been tested, and it is probably the best for Scottish conditions of all the commercial stringless varieties which have been grown at Mylnefield. It has white seeds and pale-coloured pods of a type preferred for canning.

Nineteen varieties were compared in observation plots, including ten from the Estação Experimental de Patos de Minas, Brazil. None were considered to be worth further trial.

Broad Beans

Twenty-two varieties were compared in a yield trial. Strains of the varieties Bunyard's Exhibition, Extra Lange Afhangers, Hangdown and Masterpiece, which were productive in earlier trials, again gave good yields. Of the varieties suitable for canning, the yield of one strain of Threefold White was high but the yields of other varieties, including Sugar and Lux, were low.

Brussels Sprouts

The varieties Irish Elegance, Cambridge Special and Marché de Berne again gave the highest yields in a spring-sown variety trial. Of the varieties suitable for quick-freezing, Sanda gave a lower and Irish Glacier a higher relative yield than in previous trials. The stock of the former appeared to be inferior to, and less uniform than, the stock of this variety previously tested at Mylnefield. The high yield of Irish Glacier may have been a result of the mild winter, for this variety is later in maturing than many and the relatively large number of sprouts it produced by the second pick were not spoilt by frost as in previous trials. A paper describing the results of the variety trials of this vegetable at Mylnefield during 1955-1961 is in course of publication.

Cabbage

Thirty-five late-maturing varieties—including Amager, Langendijker and a few other types—were compared in observation plots. Of the varieties which

matured in September, a strain of Amager Vinter Lav from Hansen was again extremely uniform and of very good quality, and Oakview Ballhead and Kvithamar Blåtopp were fairly good. Amager Global (Ohlsens Enke) and Winter Pride (Hurst) were the most promising as varieties for the fresh market in November and December: both strains were very uniform and formed extremely firm, round heads, but the Langendijker types on the whole produced smaller, darker-green heads than the Amager types.

Eighteen varieties were selected for small-scale tests of their capacity for winter storage, and were put into clamps during November. Amager Vintergroen (Ohlsens Enke) stored particularly well and retained its green colour better than other varieties. Langendijker Deense Witte Bewaarkool (van Loenen), Original White Cabbage (de Groot en Slot) and Winter Pride also stored well. None of the varieties survived the winter frosts when left unharvested in the field, but in general the Langendijker types were the least damaged.

Carrot

Two variety trials were conducted at Mylnefield (one harvested in August and the other in October) and one at Mr. T. Dale's farm at North Berwick. The best yields were again given by the Chantenay and Flakkeese types. The Chantenay type under the name New Stump Rooted (Clucas) produced few bolters, gave roots of a good colour and is considered to be the best for canning of all the stocks tested. A paper describing the results of these and of similar trials in 1958-59 will shortly be published.

Beetroot

The new Danish variety Formanova, which has cylindrically-shaped roots, was compared with two stocks of a similar variety, Cylindra, and two strains of Detroit Globe. Formanova gave the highest yield and its root colour was as good as that of the better strain of Detroit Globe. It produced fewer bolters than the latter variety. The roots of Cylindra were shorter than those of Formanova and their colour was inferior.

Leek

Thirty strains were compared in trials at Mylnefield and at two centres in the Clyde Valley. The varieties Cullen's Giant, Aquisition and Erda gave good yields in all three trials. Erda had fairly good habit and colour, but Aquisition was poor and Cullen's Giant intermediate in these two features.

Ridge Cucumber

Eight varieties, selected from 33 grown in observation plots the previous year, were compared in a replicated trial. The plants were raised in a greenhouse and planted in the field in mid-May. Each plot was surrounded by rows of a stiff-strawed wheat variety to provide shelter, and the plants grew well despite the exceptionally cool summer weather. Fruits were first harvested on 6 August. The Japanese F_1 variety Chojitsuochiai (Kyushu Experimental Station) again gave the highest yield, and its fruits were nearly as long and as smooth as those of a glasshouse cucumber. Other varieties which gave good yields were Delikatesse (Dippe), Perfection Ridge (Nutting), Riesen Schalgurke (Dippe) and Prolific (Sutton).

Jerusalem Artichoke

Eight varieties provided by the National Institute of Agricultural Botany, Cambridge, were compared in a replicated trial. The best of these gave more than twice the yield of some of the less productive sorts. The variety Bianke was the most productive, and Traube and Topine were also promising. Tubers of these three stocks had yellowish-white skin as compared with the reddish-brown skin of most of the other varieties tested. The trial was located in an exposed area and the tops of many plants were blown over during a gale. Some varieties, however, particularly Bianke, withstood the wind with very little lodging of the tops. (L. H. Frith, H. Taylor.)

CULTURAL EXPERIMENTS

Brussels Sprouts

A field experiment to compare the effect of spring and autumn sowing on the performance of five varieties of brussels sprout was conducted for the third consecutive year. During the mild conditions in 1959 the autumn-sown plants grew to a larger size than usual before the onset of cold weather, and as a result a high proportion of the plants of some varieties ran to seed prematurely in the spring of 1960. There were so few plants of Cluseed and Masterman in a vegetative condition at transplanting time that these two varieties had to be excluded from the trial. As in previous seasons, the yield from the non-bolting autumn-sown plants was considerably greater than that from spring-sown plants. The sprouts harvested in October from autumn-sown plants were significantly larger than those from spring-sown plants and were also paler in colour.

A field experiment to compare the effects of planting in soft and in firm ground showed no significant differences in the yield or firmness of the sprouts. It is probable that any effects produced by the treatments were masked by the exceptionally wet summer conditions.

The effect of different sowing rates in the seed bed was examined in a randomized-block trial. Seed of Cambridge No. 1 was sown on 31 March in rows 1 ft. apart, using eight different sowing rates ranging from 0·1 to 10 gm. per metre row. Plants were lifted on 10 and 23 June and 6 July, graded according to whether they were of plantable or unplantable size, and counted and weighed. Samples of the plantable grade were transplanted shortly after each lifting into a further replicated field trial from which their sprouts were harvested in January. The advantage of early transplanting was clearly demonstrated. Plants transplanted on 10 June gave nearly twice the yield of those planted on 23 June and nearly five times the yield of those planted on 6 July. Sowing rates equivalent to $1\frac{1}{2}$-3 oz. per 100 ft. of row in the seed bed gave the maximum number of seedlings suitable for planting on 10 June. (C. North, L. H. Frith.)

Carrot

A field experiment was conducted to determine the optimum sowing rate for the production of carrots for canning whole. Seed of a Chantenay type was sown in rows 8 in. apart on 12 April, 3 May, 24 May and 15 June, at rates

equivalent to 4, 6, 8 and 10 lb. per acre. This comparatively wide row width was chosen instead of 6-inch rows so that the plots could be kept free from weeds by hand hoeing, as it was thought that the use of an oil herbicide might affect the treatments differentially.

The stand of plants for any given sowing rate varied with the sowing date, and was in all cases highest for the sowing on 3 May and particularly low for that on 15 June. The highest yields of roots of a size suitable for canning whole were given by the 10 lb. per acre sowing rate for the first three sowings and by the 6 lb. rate for the last sowing. These results suggest that except for late-sown crops the usual sowing rates of from 6 to 8 lb. per acre are not high enough to give maximum yields of carrots of canning size, and that in Scotland sowing rates of at least 10 lb. per acre may be desirable.

An experiment was also carried out to determine whether carrots which had reached a size suitable for canning could be left in the field but prevented from increasing in size until required by the factory. The following three treatments were compared with untreated controls: (i) cutting off the tops; (ii) spraying with maleic hydrazide (2,500 ppm. MH as the triethanolamine salt) and cutting off the tops one week later; (iii) spraying with benzothiazol-2-oxyacetic acid (1,250 ppm.) and cutting off the tops one week later. Further growth in size of the carrots was delayed by removal of the tops, but neither of the spray treatments had a significant effect on root size. (C. North, H. Taylor.)

Cabbage

Following preliminary experiments on the winter storage of cabbage heads in clamps (see 1959-60 Report), two acres of cabbage of a tall Amager type were grown for clamping. This crop was drilled in rows 26 in. apart, using 3 lb. of seed per acre, and the seedlings were subsequently thinned to stand 12-15 in. apart in the rows.

To investigate the prospects for marketing clamped cabbage and the extent of losses which might occur in a clamp, sixteen tons of the trimmed heads were made into eight clamps in November. Each clamp contained two tons of cabbages piled about 2½ ft. high and 3 ft. wide and covered with a thick layer of wheat straw and earth. Commencing in January, one clamp was opened every two weeks and the heads were re-trimmed and marketed. The losses through trimming and desiccation were about 30% of the total weight from the clamps opened in January, and increased to over 50% for those opened in the middle of March. The trimmed heads were packed in nets each containing 42 lb. and sold locally at approximately £16 per ton throughout the period.

Eight tons of heads were used in a pilot experiment to compare different methods of clamping. The results pointed to the advantage of ventilation provided by 3-inch drainage tiles laid horizontally along the base of the clamp and projecting at intervals vertically through the top. Slightly better results were also obtained by placing the cabbage heads with their butts down rather than with the butts up. A further experiment will be done in the hope of confirming and extending these findings. (C. North, L. S. Gray.)

BRUSSELS SPROUT BREEDING

The Production of Uniform Lines

Many uniform inbred lines are being developed as material for the future production of commercial varieties. Seventy-seven such lines were grown in a trial of randomized-block design, and their yields, sprout quality and liability to internal browning compared. Individual plants for further inbreeding were selected only from those lines which gave uniformly good results. No individual plants, however good, were selected from lines which gave relatively poor average results. This technique has already produced a wide range of distinct lines which are relatively uniform and of good quality, though all lack vigour through inbreeding. In making use of this material for raising commercial varieties it will be necessary to regain vigour, and it is intended to try to achieve this by producing either synthetic varieties or F_1 hybrid lines.

Production of a Synthetic Variety

Plants from three of the uniform inbred lines were chosen for the production of an experimental synthetic variety. It was intended to use for this purpose only plants which could be maintained as clones, so that nuclear seed stocks could be reproduced from them with minimum changes in genetic constitution. Strain continuity would thus be largely assured. Consequently the chosen plants were subjected to a test of their capacity for vegetative propagation by root cuttings. The results confirmed earlier findings that there is a wide variation in this capacity, both between lines and between individual plants within a line, and very few plants gave sufficiently good results to warrant the use of the proposed technique with these clones. It seems probable that before a commercial synthetic variety can be built up and maintained from clonal material it will be necessary to breed material specifically for a high capacity for vegetative propagation.

Production of F_1 Hybrid Seed

Two experimental F_1 hybrids, produced in 1959 by using ramets of a male-sterile clone as the female parents and two uniform inbred lines as the male parents, were compared with commercial varieties in a yield trial. Both F_1 hybrids gave significantly higher yields than the best of the commercial varieties: the mean yields of each were approximately 140% of that of Marché de Berne (the highest-yielding commercial variety) and 360% of that of the control variety, Cambridge No. 1. The sprouts of the hybrids were significantly firmer than those of any other variety tested, and one of them had sprouts as large as those of Irish Elegance. These results clearly demonstrate the advantages which might be derived from the use of F_1 hybrid seed raised from parent lines selected for their performance under local conditions.

It is probable that the method used to produce these F_1 hybrids would not be economical on a commercial scale, since it would require the vegetative propagation of a large number of female parents every time a commercial crop of seed were produced. Much attention in the breeding of brussels sprouts at Mylnefield is therefore being concentrated on finding a less costly technique for the production of commercial F_1 lines.

Modification of Genetic Male-Sterility by High Temperature

Fifty-two ramets from plants showing varying degrees of genetic male-sterility were grown in pots plunged outside. On 12 December some of them were placed in a glasshouse kept at 70-80°F, others in a house at 55-65°F and others in an unheated house. Male sterility (failure to form functional stamens) was recorded in 86% of the total flowers produced by the plants in the first house, in 71% of those produced in the second house and in only 24% of those in the unheated house. These preliminary results indicate that the expression of genetic factors for male-sterility may be influenced by temperature conditions. (G. Priestley.)

The Use of Selective Gametocides

A further test with a proprietary substance (FW.450) to induce male-sterility showed that this chemical often caused severe damage. High concentrations scorched the plants and in some instances killed them. Moreover, where the formation of male-sterile flowers was induced these often failed to set seed when pollinated with normal pollen.

Late in the spring of 1960, samples of two new salts of FW.450 were received from the Murphy Chemical Company. These were applied as sprays to some available plants of *Brassica* in the open field and caused comparatively little leaf scorch. One of them, G.315, applied as an aqueous solution at the rate of 15 gm./litre just before the colour of the petals was observed, induced the formation of a high proportion of flowers without functional stamens. Some of these flowers were hand-pollinated with normal pollen from untreated plants, and gave a good set of seed. In view of these promising results it is proposed to undertake further experiments with these materials. (C. North.)

'*Glossy Foliage*'—*A Recessive Condition*

A brussels sprout plant noted in a commercial variety at Mylnefield in 1959 had leaves which were shiny and bright green, as compared with the glaucous blue-green foliage typical of this species. This condition now appears to be similar to the 'glossy foliage' mutant in green sprouting broccoli described by Anstey and Moore in 1954 (*J. Hered.*, **45**, 39). The plant found at Mylnefield was self-pollinated, and reciprocal cross-pollinations were also made with unrelated normal plants. Self-pollination gave progenies of glossy-foliage plants only. The glossy-foliage condition in brussels sprouts is therefore a recessive character, and backcrosses of the F_1 hybrids to glossy-foliage plants have been made to determine how many genes are involved in its inheritance. Electron microscope photographs of the leaves of normal, ' glossy-foliage ' and F_1 plants were made by Dr. B. E. Juniper, of the Botany School, Oxford, and showed that whereas normal plants had wax extrusions on both leaf surfaces, these were absent from the surfaces of glossy leaves. There was no evidence of a difference between the size and type of the wax extrusions in the homozygous and the heterozygous normal conditions.

It is thought that the glossy-foliage character may be a useful genetic marker to detect the occurrence of undesirable self-fertilization during the

commercial production of F_1 hybrid varieties. It is a character easily recognized, even in very small plants in a mixed seed-bed population. (C. North, G. Priestley.)

The Inheritance of Internal Browning

Studies were made on the incidence of internal browning (IB) of sprouts in progenies obtained by self-pollinating individual plants which had either high or low proportions of their sprouts spoilt by this defect. These progenies respectively contained averages of 94% and 44% of plants showing some degree of IB. Of the total numbers of sprouts sampled, those from plants of high-IB and low-IB parentage respectively contained 26% and 5% affected by IB. These results show that the tendency to develop this disorder is inherited: further studies are being made on its mode of inheritance. (G. Priestley.)

CABBAGE BREEDING

Plants selected from uniform F_3 lines derived from crosses between January King and either Ormskirk Savoy or Danish Keeping were sib-crossed in the spring of 1960. Plants of one line from similar material to this, but of a different generation, survived the winter of 1960-61 particularly well and were selected for further breeding work.

DWARF BEAN BREEDING

Thirty lines of breeding material, comprising the F_6 generations of Record × Double Princess and Record × Refugee, and the F_5 generation of Record × Fullcrop, were compared in a replicated trial with the commercial varieties Record and Masterpiece. The trial was picked at regular intervals throughout the season, and yields and pod quality were assessed. Three lines of the breeding material gave yields significantly higher than that of Record ($P < 0{\cdot}05$), and nineteen others, together with Masterpiece, gave yields as good as that of Record. Most of the lines of breeding material, including two of the highest-yielding lines, had completely stringless pods. Reserve seed of the best lines will be multiplied in 1961 for inclusion in a full-scale variety trial in 1962.

Selections were made from more than 125 lines of breeding material derived from Record × Contender, Contender × Zenevska Trzni and Double Princess × Early Blue Lake. New crosses were made between the varieties Record, Prelude and Slavia.

A wide range of dwarf selections from crosses between varieties of *Phaseolus vulgaris* and *P. coccineus* were again grown in the field. Two lines were outstanding for uniformity, vigour and pod quality, and plants were selected from these for further trial. (G. Priestley.)

PUBLICATIONS

North, C. (1960). Have you tried these vegetables? *Grower*, **53**, *Market Garden Suppl.*, 3-5.
(A description of some of the kinds and varieties of the more unusual vegetables which have been grown at Mylnefield.)

North, C. (1960). Studies in morphogenesis of *Brassica oleracea* L. II. The comparative morphology of typical heading-type cabbage plants and non-heading rogues. *J. Exp. Bot.*, **11**, 395-402.
(Non-heading rogue plants of January King Cabbage have as many leaves, and as short vegetative axes, as typical heading plants. Leaves of rogues are generally narrower

than those of corresponding age from headed plants sampled in the same crop, and their percentage dry matter content is higher. Rogue plants of January King sampled in the winter were more advanced in flower development than headed plants. These differences are discussed in relation to possible explanations of the phenomenon of heading.)

NORTH, C., and FRITH, L. H. (1960). Variety trials of vegetables in Scotland. VII. Celeriac, 1957-1959. *Rept. Scottish Hort. Res. Inst.*, 1959-60, 69-72.
(Eighteen strains were compared at Mylnefield. The most promising were Invictus, Globus and an unnamed strain.)

NORTH, C., FRITH, L. H., and TAYLOR, H. (1961). Variety trials of vegetables in Scotland. VIII. Spring-sown brussels sprouts, 1955-1961. *Hort. Res.*, **1**. (In press.)
(Fifteen commercial varieties and two experimental F_1 hybrid lines were compared at Mylnefield. Irish Elegance was the best for the fresh market and Sanda for quick-freezing. Both these varieties and Marché de Berne and Cambridge Special are suitable for gardens. The F_1 lines gave firmer sprouts and significantly higher yields than any of the commercial strains with which they were compared in 1960-61.)

NORTH, C., TAYLOR, H., and TAYLOR, MARGARET J. (1961). Variety trials of vegetables in Scotland. IX. Carrots, 1958-1960. *Hort. Res.*, **1**. (In press.)
(At three centres in Scotland twenty-three strains were compared for yield, root colour and size, and for incidence of fanging, splitting and bolting. Chantenay types, especially the strain New Stump Rooted, were judged to be the best for canning and also suitable for the fresh market. Two strains of the Flakkeese type are high-yielding varieties for the fresh market. The Swedish variety Regulus II is also a high-quality variety for the fresh market: it is not quite as productive as the Chantenay and Flakkeese types but is less prone to root-splitting than other varieties.)

PHYSIOLOGY

C. G. Guttridge

DEFOLIATION OF THE STRAWBERRY PLANT

The removal of the foliage of strawberry plants after harvest has been a remarkably effective means of increasing the fruit yields of this crop at Mylnefield. During the past four years the defoliation of various experimental areas of Talisman and Redgauntlet in the first half of August has resulted in average increases of yield in the season following treatment of 2·7 and 2·3 tons per acre respectively, increases which have raised the average annual yields of these varieties to 6·7 and 7·5 tons per acre. Large increases of crop were similarly obtained in earlier years with Auchincruive Climax, and more recently there have been indications that some other varieties may also respond in this way.

Records taken on plots of Talisman and Redgauntlet have shown that defoliation exerts its effect on cropping mainly by causing an increase in the number of flower trusses initiated in the crown buds in autumn. Several-fold increases in the numbers of trusses per plant were sometimes found, and any occasional tendency to produce barren crowns was apparently overcome completely. Consequently, yields of fruit remained consistently high from year to year. It follows from these observations that defoliation is likely to be effective only where the number of trusses formed would otherwise be below the optimum. Although the circumstances in which this may occur have not been investigated experimentally in the field, there are indications that soil fertility may be one important factor involved.

Physiologically, a deficiency of truss formation occurs in environmental conditions which favour excessive development of vegetative growth. This is in keeping with traditional ideas that excessive vigour leads to poor cropping. Defoliation therefore seems likely to be most effective where plants are grown in highly fertile soils. At sites where there is a history of biennial bearing or occasional crop failure in strawberries, it is very likely that these difficulties could be overcome, and consistently high yields obtained, by the post-harvest defoliation of mature plantations.

PHYSIOLOGICAL INVESTIGATIONS

Gibberellic Acid

Further studies were made on the capacity of gibberellic acid to promote vegetative development in the strawberry and to inhibit the induction of flower trusses.

In one experiment gibberellic acid was applied to plants housed in growth cabinets maintained at constant temperatures of 50, 55, 60 and 65°F. It was already known that vegetative development is increased when strawberry plants are grown at higher temperatures. This experiment showed that

the formative aspects of the temperature response can be simulated, at least to a partial extent, by gibberellic acid. For example, leaf-size is normally increased in response to increases either of daylength or of temperature; but gibberellic acid acted as a substitute for these factors, inducing the formation of larger leaves in short daylengths and in lower temperatures. A consequence of this was that the accumulation of dry matter also increased with the application of gibberellic acid: during 10 weeks the dry weight of plants growing at 50°F was practically doubled by a weekly application of 0·5 μg. GA per plant. At higher temperatures the increases obtained were smaller, because of the greater leaf-size of the control, untreated plants. This property of gibberellic acid may prove to be of practical value.

These results, with others from similar experiments, support the general hypothesis that gibberellic acid acts either by stimulating the production of a natural promoter of vegetative development or by directly replacing the native hormone at the sites of response. The second of these alternatives seems the more probable, since gibberellic acid is able to induce elongation of the main stem of the crown: this is a formative response which cannot be induced by manipulation of the environment and therefore, presumably, not by the native hormone. On this reasoning it would seem unlikely that gibberellic acid is identical with the native hormone, although it may be similar to it. (C. G. Guttridge.)

Interaction of Maleic Hydrazide and Gibberellic Acid

A series of experiments was done to investigate the possible interactions between maleic hydrazide and gibberellic acid when both are applied to strawberry plants. In many respects these substances affect vegetative growth processes in opposing ways, and it was thought that maleic hydrazide might inhibit growth by interfering with the action of naturally produced gibberellins. If this were so it might be expected that the inhibitory effects of maleic hydrazide could be reversed by treatment with exogenous gibberellic acid.

In one experiment maleic hydrazide was applied as a spray at weekly intervals to plants of the variety Talisman at concentrations of 0, 125, 250 and 500 ppm. Gibberellic acid was also applied weekly at 0, 6·25, 12·5 and 25 ppm., in all factorial combinations with the maleic hydrazide treatments. Records were made of the numbers of runners inhibited and also of runner lengths, petiole lengths and the rate of growth of selected petioles. There was no suggestion that gibberellic acid neutralized or reversed the inhibition induced by maleic hydrazide: on the contrary, it clearly increased the inhibitory effect produced. For example, both the percentage of runners inhibited by maleic hydrazide, and also the duration of inhibition, increased directly with increasing levels of gibberellic acid treatment.

Two further experiments to extend these observations both confirmed that plants treated with gibberellic acid were more susceptible to inhibition by maleic hydrazide than untreated plants. This effect was not confined to the runners but was found in all the vegetative growth measurements made, including stem length, petiole length and leaf area. (P. A. Thompson.)

Grafting

The inter-grafting of plants is a technique which has been used by several workers in studies of flower induction among closely related species. Scions have been induced to flower by the supposed transference through the graft union of a flower-promoting principle present in the stock.

Experiments were done to see if this technique could be used to study the different systems of flower truss formation shown by 'perpetual' and 'non-perpetual' varieties of strawberry. It became clear from the results that this is not an easy technique, although the stolons formed graft unions fairly readily. Nevertheless, grafts between the non-perpetual *Fragaria vesca* and the everbearing (perpetual) *F. vesca semperflorens* showed that flower truss initiation in scions of the former could be influenced by the photoperiod to which leaves of stock plants of the everbearing type were exposed. In a further experiment, scions of the perpetual type were not inhibited from truss formation when grafted to stocks of the runnering type. (C. G. Guttridge.)

Development of the Strawberry Fruit

During the summer of 1960 several experiments were done to study the effect of a number of auxins on fruit development in the strawberry.

Sprays of gibberellic acid at 20 ppm., and of indole butyric acid, indole acetic acid and β-naphthoxy acetic acid each at 100 ppm., all failed to stimulate any parthenocarpic development when applied twice-weekly throughout the flowering period to emasculated flowers of Talisman.

In a second experiment, Talisman plants in the glasshouse were sprayed once with maleic hydrazide at 1,500 ppm., either on the day that the primary flower opened or five, ten or fifteen days after its opening. A further set of plants was left unsprayed. In addition, half of the plants in each of these treatments were sprayed twice a week with β-naphthoxy acetic acid at 100 ppm., from the time that the plants started to bloom until the last fruits ripened. The fruits were picked at 3- or 4-day intervals and weighed individually, and the numbers of viable and non-viable achenes were counted on samples of fruit from each treatment.

Maleic hydrazide applied within ten days of the opening of the primary flower almost entirely prevented the formation of viable achenes on the primary and secondary fruits; but plants sprayed fifteen days after the primary flower had opened formed fruits with as many viable achenes as the controls.

Fruit development was not dependent on the presence of viable achenes, and many fruits swelled normally in their absence. Treatment with β-naphthoxy acetic acid slightly increased the average weight of the individual fruits when the number of viable achenes produced was low, but decreased it when the number was high. (P. A. Thompson.)

Species of Fragaria *other than the Cultivated Strawberry*

In a short study of a number of *Fragaria* species, most of them supplied by Mr. R. D. Reid, some interesting characteristics were observed which may prove useful in physiological investigations. For example, *F. virginiana* is

very highly sensitive to photoperiod and should make a good test plant. The Ambato strain of *F. chiloensis*, when grown in this country, shows a high degree of vegetative development and shyness in flowering, although it fruits almost continuously in the nearly constant daylength and relatively cool temperatures of its native habitat, the Ambato region of Ecuador, which lies at a high altitude near to the equator. Another strain of *F. chiloensis* is not so strongly vegetative.

The native wild strawberry of Britain (*F. vesca*) has been found in several experiments to be very shy to flower, initiating trusses only after prolonged short-day treatment. Experiments are now in progress to see if this is due to the high fertility of the potting soil used in this work, compared with that of soils in many natural habitats where the species flowers freely. (C. G. Guttridge.)

Duchesnea indica

Past experiments at Mylnefield have led to the hypothesis that the developmental growth cycle in strawberry is regulated principally by a hormone which promotes vegetative development and inhibits flower truss formation. To see whether a similar hormone system could reasonably be postulated for a related species, growth responses to environmental factors and to gibberellic acid were studied in *Duchesnea indica*, a plant closely related to the genera *Fragaria* and *Potentilla* and somewhat similar in growth habit to *Potentilla reptans*. The responses found showed certain similarities to those of the strawberry: petiole length specifically, and the vegetative development of the plant in general, including the length of the internodes of axillary shoots, were increased by increasing the daylength or by applying gibberellic acid. The effects of daylength and gibberellic acid on flowering, however, seemed to involve the emergence rather than the initiation of the flowers. Some delay was observed in flower initiation after the application of gibberellic acid, but this appeared to be due to a general retardation in the growth of the axillary shoots on which the flowers of this species arise. No structures alternative to flowers were formed. Thus the effects of long daylength and of the application of gibberellic acid on petiole length and general vegetative development are similar in *D. indica* and the strawberry, suggesting the operation of a similar hormone in the two species; but it is clear that the flower-forming processes of *D. indica* are not influenced by such a hormone. (C. G. Guttridge.)

FIELD INVESTIGATIONS

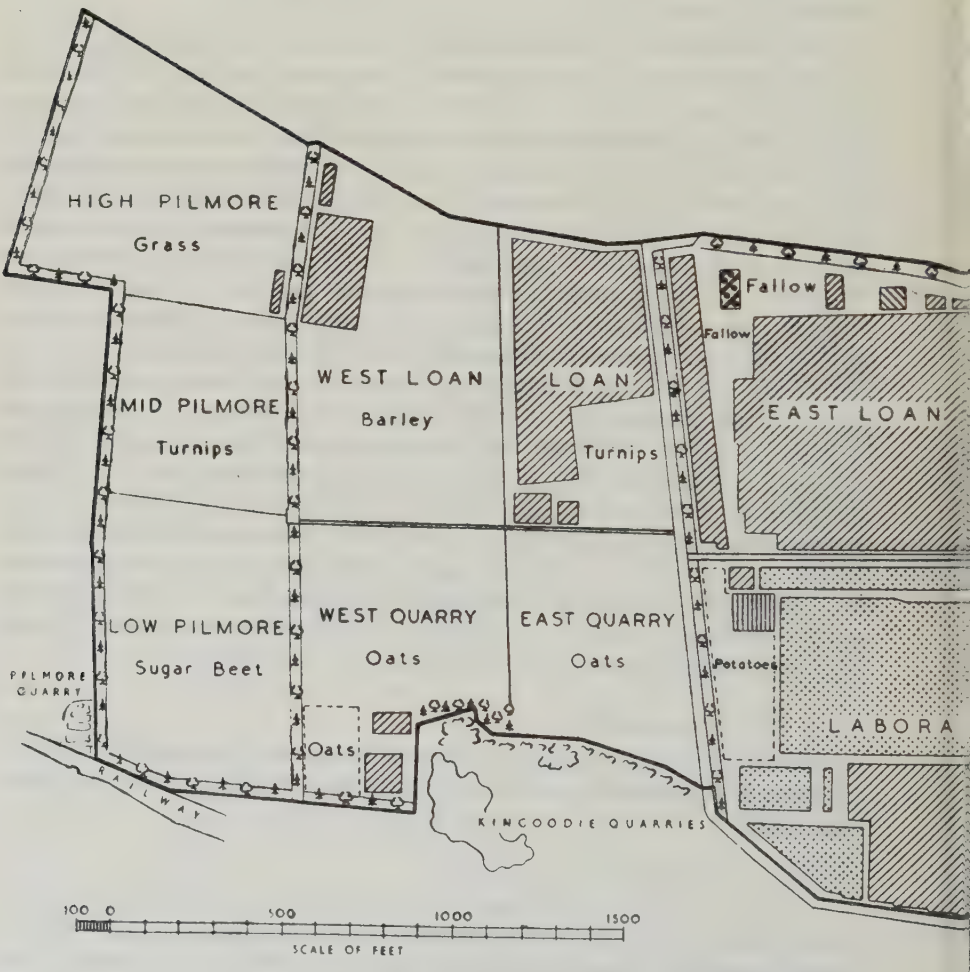
About two acres of strawberries for experiments and runner-beds were successfully established in the north-west area of Bullion South Field in spring 1960.

Seasonal Growth Pattern

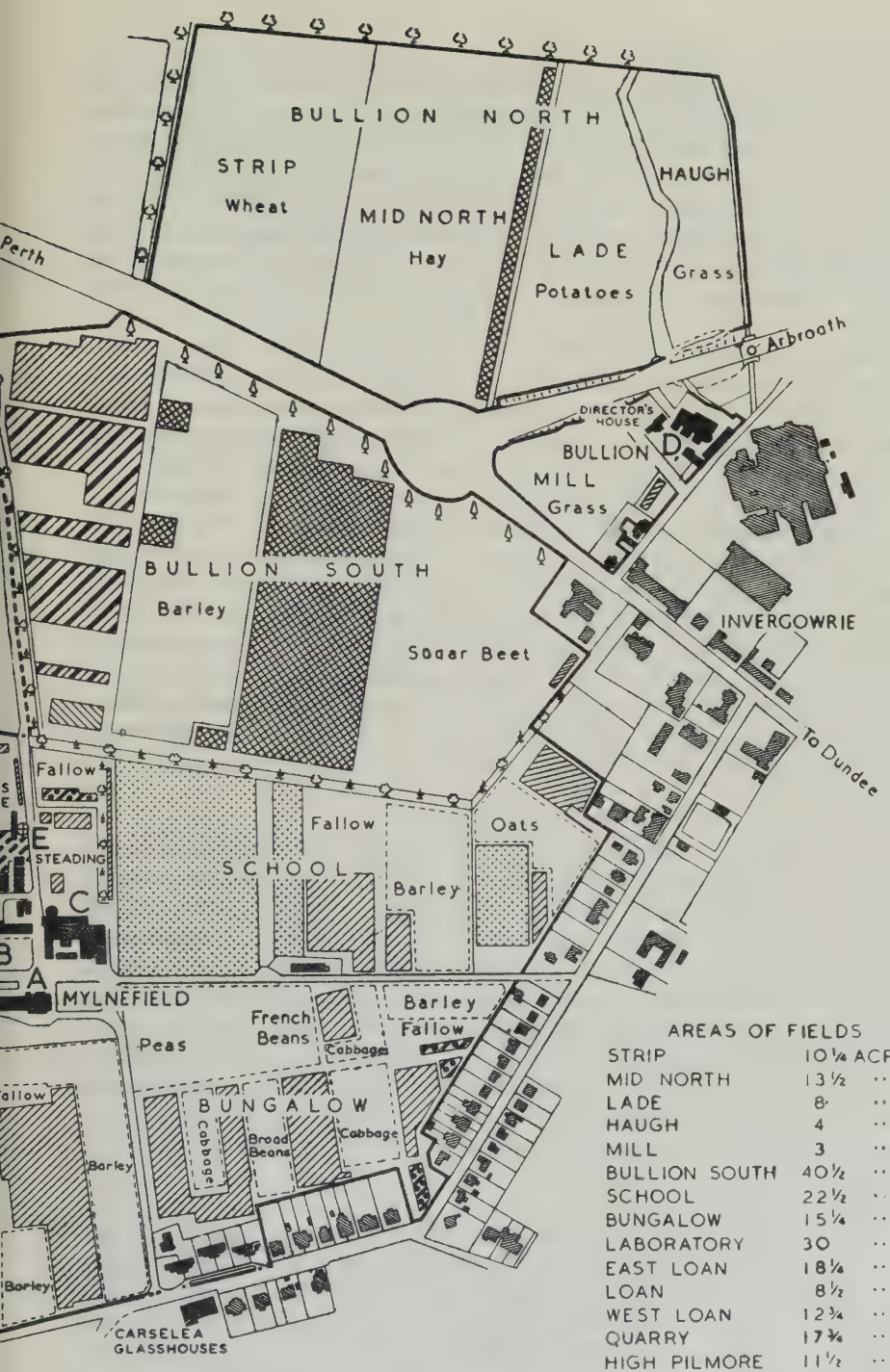
A detailed study of the seasonal growth pattern of the variety Talisman is being made by taking 4-weekly records of leaf emergence, petiole lengths, runner formation, branch crown formation and flowering. These records were started on plants planted on 4 May 1960 and will be continued during 1961.

EXPERIMENTAL PLANTATIONS, 1960.

- TREE FRUITS
- SMALL FRUITS.
- VEGETABLES.
- POTATO VIRUS EXPERIMENTS.
- POTATO WEED CONTROL EXPERIMENTS.
- SOIL-BORNE VIRUS EXPERIMENTS.
- GENERAL NURSERIES.
- SMALL FRUIT NURSERIES.
- MAIN SHELTER BELTS.
- PLUNGE BEDS.
- A ADMINISTRATIVE & LABORATORY BUILDING.
- B GLASSHOUSE AREA.
- C GENERAL PURPOSE BUILDINGS.
- D FARM BUILDINGS
- E WIND SPEED & DIRECTION RECORDING SITE.
- M MAIN METEOROLOGICAL SITE.



SCOTTISH HORTICULTURAL
MYLNEFIELD AND
INVERGOWI



AREAS OF FIELDS

STRIP	10¼	ACRES
MID NORTH	13½	,,
LADE	8	,,
HAUGH	4	,,
MILL	3	,,
BULLION SOUTH	40½	,,
SCHOOL	22½	,,
BUNGALOW	15¼	,,
LABORATORY	30	,,
EAST LOAN	18¼	,,
LOAN	8½	,,
WEST LOAN	12¾	,,
QUARRY	17¾	,,
HIGH PILMORE	11½	,,
MID PILMORE	7	,,
LOW PILMORE	10¾	,,

EARCH INSTITUTE
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DEPARTMENT OF AGRICULTURE & FISHERIES FOR SCOTLAND
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Temperature and Flowering

Non-defoliated plants of Talisman and Redgauntlet were covered by cloches for periods of three weeks, commencing on 26 August, 16 September or 7 October 1960, and crowns were lifted on 30 November for dissection. The plants of Talisman cloched from 16 September to 7 October initiated fewer flowers than plants cloched earlier or later or not cloched at all, but no such differences were observed in Redgauntlet. This supports the suggestion that abnormally high autumn temperatures may be responsible for the poor flower initiation which sometimes occurs in Talisman.

Defoliation and Foliar Application of Nitrogen

Talisman and Redgauntlet plants, some of which had previously been defoliated in 1959, were mown in 1960 either on 27 July or 19 August. Similar plants were retained intact as controls. The treatments were subdivided to investigate the effect of three successive spray applications of urea given at a concentration of 3% (with wetter) on 1 and 15 August and 24 September, which provided nitrogen at a total rate of 53 lb. per acre. Dissections in December showed that in both varieties the highest numbers of flowers were present in the plants which had been defoliated on 19 August. Most of those defoliated on 27 July also contained more flowers than the intact controls. The nitrogen applications apparently had no effect on flower formation in the controls and gave varying results in the mown plants. In both varieties the highest numbers of flower trusses were found in plants which had been mown on 19 August 1960 and had neither been defoliated in 1959 nor sprayed in 1960 with foliar nitrogen.

Defoliation and Soil Application of Nitrogen

Crown samples for dissection were taken on 28 November from a Pomology Department plantation of Redgauntlet on which a comparison is being made of the effects of defoliation on three dates in August in combination with spring and autumn applications of nitrogen in the form of ammonium sulphate (see p. 21). Plants grown without nitrogen and defoliated on 22 August 1960 contained the highest number of flower trusses in the bud, while plants which had received nitrogen both in spring and autumn and had been defoliated on 1 August contained the fewest. In general, the nitrogen dressings appeared to have depressed flower initiation in the defoliated plants and increased it in the intact plants. Inflorescence counts will be made in the field in spring 1961 to verify these results.

Scottish Fruit Trials

Crown samples were also taken on 4-6 October and 1-2 December from eight strawberry varieties growing in the Scottish Fruit Trials plots at Mylnefield (see p. 24). Post-harvest defoliation had again been applied to these on a sub-plot basis. It was found that flower initiation had been increased considerably in Talisman, Redgauntlet and Senga Sengana, increased slightly in Cambridge Vigour, Cambridge Rearguard and Merton Princess, and decreased in Senga 54. No effect was detected in Royal Sovereign. The result in Cambridge Rearguard was not as outstanding as in 1959, when many

non-defoliated crowns of this variety failed completely to initiate flowers. It is possible that the difference between the two years was due to the unusually high autumn temperatures of 1959. (D. T. Mason.)

Maleic Hydrazide for Runner Control

The 1959-60 Report described an experiment on the use of maleic hydrazide to control runner production in the strawberry varieties Talisman, Redgauntlet, Cambridge Favourite and Cambridge Vigour. Maleic hydrazide was applied on 23 June 1959 at concentrations of either 0·1, 0·15 or 0·2%, and the sprays were repeated 4-6 weeks later when healthy young stolons again began to appear. The crop from this experiment was harvested in 1960, when records were also made of the height of the plants and the number of flower trusses which they produced. These measurements showed that treatment with maleic hydrazide at any of the concentrations had slightly reduced the vigour of the plants in all varieties.

The effect of the treatments on cropping depended largely on variety. The yield of Redgauntlet was greater where the runners had been controlled by maleic hydrazide than where they had been removed manually, but only in one case was this increase significant. Talisman showed slight reductions in yield, but this again was significant for only one treatment. However, the cropping of Cambridge Favourite was quite severely reduced by all the maleic hydrazide treatments, and there was also a moderate reduction in the yield of Cambridge Vigour. Comparison of the cropping data with counts of flower trusses showed that yields varied directly with the numbers of trusses present, suggesting that the slight loss of vigour caused by the treatment did not of itself limit crop production.

In a similar experiment started with the same four varieties in spring 1960, the plants were sprayed with maleic hydrazide at the following concentrations and times: (i) 0·3% on 22 June; or (ii) 0·2% on 22 June and 0·15% on 25 July; or (iii) 0·15% on both 22 June and 25 July. In unsprayed controls the stolons were removed by hand at regular intervals until early August and were then left unchecked. When all runnering had ceased, a record was made of the numbers of primary stolons present. Runner control in the sprayed plants was found to be equal to or better than that achieved by hand-removal, and the runner growth produced was in no case sufficient to interfere seriously with routine cultivations.

Prior to 1960, experiments on the use of maleic hydrazide for runner control were done only on maiden plantations, which were deblossomed to prevent fruiting. Problems of maleic hydrazide residues in fruit and possible losses of yield after spraying make it unlikely that this chemical can safely be used in plantations which are cropping. However, an experiment to examine the consequences of treating fruiting strawberries between flowering and ripening (the period when the first stolons emerge) was done during 1960. In this, plants of Redgauntlet, Talisman and Royal Sovereign were sprayed with maleic hydrazide at concentrations of 0·15, 0·2 or 0·3% just after the peak of the flowering period, and a fourth series of plants was left untreated.

Young leaves which emerged after the plants of this experiment were sprayed showed severe chlorosis, and the new growth in Royal Sovereign

particularly was severely stunted. Runners were well controlled at all the treatment levels, and the 0·3% treatment gave an almost complete control in all three varieties for the remainder of the season. The yield records, however, showed that each of the treatments reduced the cropping of Talisman and Royal Sovereign by at least one-half. In Redgauntlet the fruit ripened earlier than in the controls and the yield was not significantly reduced. Samples of fruit were taken to be analysed for maleic hydrazide residues, but the results of these tests are not yet available. (P. A. Thompson.)

Cold Storage Experiments

Runner-plants of Talisman and Redgauntlet formed in 1958 were cold stored in 1959 from early spring until 30 July, and then planted in the field at a close spacing of 9 in. apart in rows 3 ft. apart. New runners formed in 1959 were added to the experiment as controls on 18 August, the approximate date when they first became available. Growth in the autumn appeared to be satisfactory in spite of dry weather, but about a fifth of the plants died during the winter or early spring mainly as a result, apparently, of frost-lifting, aggravated by excessive drawing away of soil from the rows during hoeing. This was the first time such a loss had been experienced with cold stored runners. Many of the surviving plants were damaged, and the crop in 1960 was smaller than might have been expected. The control runners suffered similarly and also cropped indifferently. The yields of marketable fruit from this experiment in 1960 averaged 20·5 oz. per yard of row (equivalent to about $2\frac{3}{4}$ tons per acre) for the cold stored Redgauntlet and 16·1 oz. per yard for the cold stored Talisman, as compared with 12·2 and 12·0 oz. per yard for the freshly-lifted runners of the two varieties. Higher yields than these were obtained from stored runners in previous years, especially after planting in June or early July. A further trial was planted in 1960. (C. G. Guttridge, D. T. Mason.)

PUBLICATIONS

Research Papers

Thompson, P. A., and Guttridge, C. G. (1960). Role of leaves as inhibitors of flower induction in strawberry. *Ann. Bot.* N.S., **24**, 482-90.

(The effect of leaf maturity on the capacity of leaves to regulate fruit truss initiation in different photoperiods was studied in the strawberry variety Talisman, a facultative short-day plant.

When mature foliage was removed to leave only two immature leaves on each plant, truss induction occurred in longer photoperiods than in intact plants. Conversely, when young foliage was removed to leave only three mature leaves, shorter photoperiods were required for induction than for intact plants. Intact plants in constant darkness and totally defoliated plants in continuous light both initiated fruit trusses, but intact plants in continuous light failed to do so. These results support the hypothesis that the photo-periodic control of flowering in strawberry operates through a flower inhibitor produced in the leaves. They also show that mature leaves are more inhibitory than immature ones, and that the inhibitory activity of any leaf decreases with decreasing photoperiod.)

Guttridge, C. G. (1960). The physiology of flower formation and vegetative growth in the strawberry. *Bulletin de l'institut agronomique et des stations de recherches de Gembloux: série extraordinaire éditée à l'occasion du centenaire de l'institut agronomique de l'état*: **2**, 941-48.

(Increase of daylength promotes vegetative development in the strawberry and depresses flower truss initiation. The same effects result from increasing the growing temperature, subjecting the plants to winter chilling or applying gibberellic acid treatments. It is suggested that the apparent antagonism between vegetative and floral development is a fundamental problem in the quest for higher fruit yields. Excessive vegetative development tends to predispose the plants to a deficiency in numbers of flower trusses, whereas insufficient vegetative development restricts the later development of the truss and the fruit crop.)

GUTTRIDGE, C. G., (ANDERSON, M. M.,) THOMPSON, P. A., (and WOOD, C. A.) (1961). Post-harvest defoliation of strawberry plantations. *J. hort. Sci.*, **36**, 93-101.

(Yields of the strawberry varieties Talisman and Redgauntlet at Mylnefield were increased, sometimes substantially, by cutting and removing the foliage in August, soon after completion of the previous harvest. The largest increases were obtained when the yield of unmown plots was low.

These increased yields were the direct consequence of the increased numbers of fruit trusses initiated in autumn. Dissections in 1959 showed that the additional fruit trusses were initiated either immediately following defoliation or after several weeks' delay, when a new canopy of leaves had formed. A theoretical explanation of the effect is offered and commercial application of the practice is recommended for Scotland.)

THOMPSON, P. A. (1961). The use of maleic hydrazide for the control of runners in strawberry plantations. *Proc. 5th Brit. Weed Control Conf.*, 1960, **2**, 397-404.

(Maleic hydrazide in the form of the triethanolamine salt was used to control runner production in the strawberry varieties Talisman, Redgauntlet, Cambridge Vigour and Cambridge Favourite. Records of runner production in the field had shown that runners formed by primary stolons which emerged in July gave rise to large numbers of secondary stolons and runners, and that for successful control it was therefore necessary to inhibit the growth of primary stolons. Maleic hydrazide was applied on 23 June at 0·1, 0·15 or 0·2%, and the plants were re-sprayed when healthy stolons again began to emerge. Successful runner control was achieved with all the treatments in the varieties Talisman, Cambridge Vigour and Cambridge Favourite, but the results in Redgauntlet were variable. The sprayed plants were slightly reduced in height in the following spring as compared with untreated controls.)

THOMPSON, P. A. (1961). Evidence for a factor which prevents the development of parthenocarpic fruit in the strawberry. *J. Exp. Bot.*, **12**, 199-206.

(Observations on fruit development in the cultivated strawberry (*Fragaria* x *Ananassa* D.) are interpreted as showing that in unpollinated flowers the development of the fleshy receptacle ceases at anthesis because of an inhibitory factor produced by the maturing carpels. It is suggested that one of the consequences of pollination (or of fertilization) is that this factor is neutralized and the tissues become responsive to stimulatory substances produced either by the parent plant or by the fertilized carpels. Receptacles on which pollination is confined to a single carpel swell only around the point of insertion of that carpel. No swelling occurs beneath neighbouring unfertilized carpels. Similarly, when plants are treated with gibberellic acid, swelling occurs only at the base of the receptacle and not in the areas occupied by unfertilized carpels. Parthenocarpic fruits were produced in two ways, both of which depended on the suppression of carpel development. In one case they were induced to develop by modifying the plant environment so that leafy bracts were produced instead of carpels. In the other, the development of the carpels was specifically inhibited by applications of maleic hydrazide at the time of their formation. When carpels were only partially suppressed, swelling of the receptacle occurred in areas either free from carpels or occupied by fertilized carpels, but never in areas occupied by unfertilized carpels.)

Thompson, P. A. (1961). Some factors regulating the use of maleic hydrazide for runner control in strawberry plantations. *Hort. Res.*, **1**. (In press.)

(A study was made of the conditions under which maleic hydrazide fails to give an adequate control of runner formation in strawberry plantations. The effect of maleic hydrazide on flower initiation in the strawberry was also investigated.

One cause of reduced runner control was thought to be the presence of runners already rooted at the start of treatment. To test this possibility, large plants of Talisman were allowed to form runner chains and were then treated with maleic hydrazide at 2, 4, 6 or 8 mg. per plant. Runners which were rooted when the experiment began were very tolerant of the treatments and soon recommenced the production of secondary stolons. Emerged stolons which had not formed roots at the time of treatment, however, were effectively inhibited, as also were those which emerged within two weeks of treatment. It is suggested that when runner chains are present the maleic hydrazide is translocated rapidly to the stolon-tips, so that the extent and duration of inhibition in other parts of the plant is greatly reduced as compared with that obtained when the parent plants are free from rooted runners.

The formation of flower initials in the variety Auchincruive Climax was inhibited by maleic hydrazide at concentrations which did not reduce the rate of leaf initiation. The effect did not persist for more than two plastochrons after treatment, and, provided that care is taken not to spray when flowers are being formed, this tendency of maleic hydrazide to prevent flower initiation should not reduce its value for runner control.)

General Paper

Guttridge, C. G., (and Wood, C. A.) (1961). Defoliation of Strawberry Plants. *Scot. Agric.*, **41**, 39-42.

(A report for growers on the results of several years' experimental work at Mylnefield on the post-harvest defoliation of strawberry plantations.)

GENETICS

G. Haskell

RUBUS INVESTIGATIONS

Adaptability of Local Wild Blackberries

Field plantings have now been made of 33 families of blackberry raised from seed harvested from plants growing wild in east Perthshire, south Angus and north Fife (see 1959-60 Report). Each family comprises 10 plants, a number which should be sufficient for critical identification: this, however, will have to await the recognition of minor characters in both the first and second year stems.

These families should add to our knowledge of the *Rubus* flora of vice-counties 85, 88, 89 and 90, while their behaviour in the field, particularly in respect of overwintering, growth-vigour and fruiting, will enable an assessment to be made of their value as breeding material. This is necessary prior to introducing into them the gene for thornlessness with the object of obtaining locally-adapted thornless varieties.

In addition, these families will be used to assess the amount of variation *within* polyploid apomictic species. This should be valuable for an understanding both of the breeding behaviour of blackberries in general and of the apomictic system in particular. Chromosome numbers will also be determined, as there are still many wild 'species' of *Rubus* in Britain (especially in Scotland) for which this has not yet been done. It is expected that most of these species will prove to be tetraploid, but it is possible that some will show higher ploidy. Any that do so will be of potential value as breeding material, because raising the ploidy in *Rubus* often produces increased vigour and larger inflorescences and fruits.

Germination of Rubus

Although the wild blackberry seed referred to in the above section had all been gathered and cleaned under similar conditions, the families differed widely in the proportion of their seed which germinated by early May. One family by this time showed 54% germination, 17 families not more than 10% and two families none at all. Some families gave proportions of abnormal seedlings such as pleiocots, tubular seedlings (i.e. with the cotyledons united into a tube), seedlings with yellow-green leaves, and seedlings with picotee cotyledons (i.e. with yellow edges to the green cotyledons). The family with the highest germination percentage also appeared to have the most vigorous seedlings, but whether earliness and vigour at the germination stage are associated with the growth of early and vigorous adult plants remains to be seen. Furthermore, since earliness in germination could play an important part in the establishment of a *Rubus* species or hybrid in nature, it is of interest that the earliest and most vigorous of these families is one that appears to have

been gathered from a hybrid of *R. caesius*. As *R. caesius* itself is not recorded for this area, this finding, if confirmed, will support the belief that early germination and seedling vigour are important in the natural establishment of *Rubus* hybrids.

In an experiment with raspberry seeds obtained by selfing the variety Lloyd George, it was found not only that germination was delayed if the seed was left to dry without first removing the drupelet skin and flesh (the exocarp and mesocarp), but also that the resultant growth was slower. This suggests that the outer and middle layers of the drupelet wall exert an inhibitory effect on both processes.

Breeding Thornless Tetraploid Blackberries

The F_2 generation of the cross Merton Thornless x Himalaya Giant (*R. procerus*) has now been planted out and the plants are expected to fruit for the first time in 1961. Ninety-five seedlings believed to be thornless were retained from an F_2 population of nearly 2,500 (i.e. less than 4% of the total), the potentially thorned segregants being detected and discarded at the cotyledon stage. All 95 plants have overwintered, but unfortunately they include 14 mis-classifications, which escaped detection at the cotyledon stage possibly through having few glands. It is suggested that these are of sssS constitution, i.e. that they are simplex for the 'thorned' gene, a possibility which will be investigated. Several of the 81 truly thornless seedlings are vigorous and look promising.

Genetical Variation in Loganberry

Stocks of loganberry are known to be variable, but it is not known to what extent this is due to genetical factors. Studies have therefore been initiated to try to determine the causes of observed variability and to discover whether loganberry-like seedlings of higher or of lower ploidy can be obtained. One method of separating aberrant chromosomal types is based on seed size. More than 17,000 seeds from four clones of loganberry were therefore divided by eye into three size groups by removing separately the smallest and the largest seeds. These constituted 7·7% and 2·4% respectively of the total. The small seeds had a mean weight of 9·15 mg., the large seeds a mean of 15·81 mg. and the remainder a mean of 12·93 mg. The small and large seeds and samples of the remaining seed were sown, and the resultant seedlings are now field planted and available for biometrical and cytological investigation. Unfortunately twin-seedlings, which often indicate the occurrence of polyhaploidy in other crops, were not observed.

A similar technique is being tried out with seed obtained by selfing six diploid varieties of raspberry, to determine whether haploids and polyploids can be found in this way and their frequency increased. The method is also being tested with several apomictic tetraploid cultivars of blackberry to see if it will enable higher proportions of sexual recombinants, as well as of polyhaploid, polyploid and other aberrant progeny, to be separated from the mainly apomictic population. (G. Haskell.)

CYTOLOGICAL INVESTIGATIONS

Ribes: *Satellites of Species-Hybrids*

No conspicuous size differences exist between the chromosomes of the two parental genomes of the F_1 hybrid of black currant (*R. nigrum*) and gooseberry (*R. grossularia*). There are 14 metacentric chromosomes and one pair of satellited chromosomes in the black currant variety Amos Black, but in the F_1 hybrids with gooseberry only one satellited chromosome has been observed. It was thought that the gooseberry genome might lack the satellited chromosome, but the presence of a pair of satellites in the complement of an unnamed variety of gooseberry has now been confirmed. If a reduction in the number of satellites is a constant feature of the F_1 species-hybrid, it is suggested that this could be a useful marker in plant breeding studies. Owing to chromosomal similarities, it has not yet been possible to determine whether the single satellited chromosome in this F_1 is always contributed by the same parent.

Rubus: *Somatic Instability*

Further examination was made of the cytologically unstable hybrid described in the last Report. The somatic chromosome number in the root-tips was shown eventually to range from 9 to 68, with the mode constant at 35. The parents of the hybrid and also its normal sibs were $2n=28$. With some difficulty a count was made from a stipule, and gave $2n=39$: hence the shoot system as well as the root system is unstable. The stipule chromosomes were broader than those of the root-tips. This may have been due to changes during pre-treatment, although it is a condition which has also been recognized in *Crepis* species-hybrids. Altogether 113 cells with less than 35 chromosomes, 44 cells with more than 35 chromosomes and 259 cells with precisely 35 chromosomes were observed. In later observations it was noted that cells of the same chromosome number tended to be associated in groups.

The distribution of the satellited chromosomes was irregular. Although their number generally increased with the total number of chromosomes, the correlation was not precise: cells with greater than the $4n$ number of chromosomes showed much variation in satellite numbers, while in one diploid ($2n=14$) cell as many as four satellited chromosomes were found. This suggests that the chromosomes of both genomes are distributed very irregularly between the cells during mitosis. There was a significant positive correlation between chromosome number and cell size, regardless of aneuploidy. (N. N. Tun.)

STRAWBERRY INVESTIGATIONS

Spring Chlorosis of Strawberry

Twenty-four thousand seedlings of known parentage were grown and observed in the field between 1956 and 1960, when this phase of the investigation ended. The records from this work have been analysed and the results are being prepared for publication.

From observations of the earliest planted of these seedlings over four successive seasons, and from knowledge of affected varieties like Auchincruive Climax, it is apparent that the change from normal green to June Yellows is irreversible. A slightly lower incidence of affected seedlings was recorded in certain families in 1959 than in 1958, but this is attributed to the fact that observations in 1959 were necessarily infrequent and not all made at the optimum time.

When several plants of the affected varieties Auchincruive Climax and Madame Moutôt were used in crosses with a number of green varieties, significant differences occurred between the proportions of June Yellows seedlings in progenies from individual affected plants. Significant differences in the proportions of yellow seedlings were also observed between progenies raised in the same year and from the same plants but from different inflorescences of the mother-plant. Although no large differences were consistently observed between reciprocal crosses, there was some tendency for the incidence of June Yellows to be higher when the affected variety was used as the pollen parent.

The proportion of affected seedlings produced and the rate at which the abnormal condition developed generally depended only slightly on the green variety with which Climax was crossed, thus indicating that neither the genes nor the cytoplasm of the green variety influenced June Yellows development. Exceptions, however, were the cross with Royal Sovereign, which gave a low proportion of affected seedlings, and the cross with Tardive de Leopold, which gave both the highest incidence and the highest rate of development of yellows. Since Tardive de Leopold is male-sterile and cannot therefore be crossed reciprocally, any differential effect of its genes or cytoplasm in causing enhancement of the condition could not be distinguished immediately. However, reciprocal crosses between Royal Sovereign and Climax indicated that it was the genes of the former, rather than its cytoplasm, which depressed June Yellows development.

This brief summary indicates that the observations arising from this study cannot be interpreted satisfactorily on a hypothesis that June Yellows is inherited through nuclear genes. The causal factor must be extra-chromosomal, and is therefore a 'plasmagene.' This interpretation accords with recent suggestions made by other investigators. From the pattern of variation in selfed and crossed families it is concluded that concentration of the plasmagene increases continuously in affected plants, and that random variations in distribution at cell division lead to the variations in heredity observed between different parts of a plant and different plants of a clone.

The origin of such a plasmagene is a matter of speculation. Apart from the easily seen plastids, it is known that other, less readily observable cytoplasmic bodies reproduce independently of the nucleus. Mutation of a particle of this kind could lead to a release from the controls normally restricting its multiplication, and this might result in an abnormal plant condition. Alternatively, a plasmagene might arise from a virus. Experiments now in progress in the Virology Department show that some viruses can be transmitted through gametes, and evidence from other sources indicates that loss of virulence and of infectivity sometimes accompanies the transmission of

a pathogen by gametes of its host. Although the alternative hypotheses of endogenous or exogenous origin cannot be distinguished by the present experimental evidence, the virus hypothesis is favoured and experiments are now being designed to obtain further information on this possibility.

These observations and conclusions offer little hope that June Yellows can be bred out of affected lines. The use of affected varieties for breeding purposes can therefore be justified only where no reasonable alternative exists or when seedlings so raised will grow in places where other varieties fail. The genetic approach most likely to succeed would be to use varieties prone to June Yellows as seed parents only, and to outcross their progenies repeatedly by green types.

The symptoms of inherited chloroses transmitted by Perle de Prague and Cambridge Early in the course of this work differed markedly from those of June Yellows. Their mode of inheritance also differed, for progenies were shown to be homogeneous, indicating chromosomal control of these chloroses.

Researches in the U.S.A.

The period from early summer 1959 until the summer of 1960 was spent at the Department of Horticulture of the New Jersey Agricultural Experiment Station, Rutgers University. Studies were continued on the yellows complex in strawberries, and a study was made under the direction of Dr. L. F. Hough on the inheritance of resistance to strawberry red core disease.

June Yellows is not at present a serious problem in America. In New Jersey only one commercial variety, Dixieland, was seen to show the symptoms, but some affected seedlings were seen in breeding plots. Replacement of an affected variety presents little difficulty, because a choice of suitable varieties is available in most areas and many growers pick only one crop before replanting. On the other hand, an inherited disorder characterized by white streaks and stripes, often parallel to the leaf margins, was found to be widespread in seedlings from many strawberry varieties. This disorder, which is independent of June Yellows and has previously been seen by the writer only in Dutch seedlings, may be expected to occur if American varieties are utilized to any considerable extent in a breeding programme.

The inheritance of resistance to red core was studied in seedling families bred from selfs and crosses of resistant and susceptible varieties. Under the conditions of the experiment no successful infection was obtained either in naturally infected soil or in soil inoculated with pure cultures of the pathogen, but extensive root infection was obtained by adding active zoospore suspensions to the water in which seedling plants were growing in a growth chamber. The number of seedlings studied was reduced by other diseases and by damage in handling, so that accurate genetic analysis of the results was not possible; but significant differences in proportions of seedlings affected were shown between families of different parentage. The variety Surecrop conferred greatest resistance to the disease. Included in the tests were plants of *Fragaria virginiana* grown from seed collected in north-east U.S.A. The results indicated that resistance to the common American physiologic race of red core is not rare in this species. (A. B. Wills.)

OTHER FRUIT CROPS

During the period spent in the north-eastern U.S.A., the opportunity was taken to become acquainted with other fruit crops, particularly blueberries and nectarines. The commercial growing of high-bush blueberries has recently made remarkable progress, which is related to the breeding and introduction of improved, large-fruited varieties. Only limited attempts have been made to grow this specialized crop in Britain, but it would appear to have great potential value for the future. (A. B. Wills.)

TOMATO INVESTIGATIONS

Variation in Cultivated Tomatoes in Scotland

After a survey of the glasshouse tomato industry of the Clyde Valley, which revealed that a wide range of varieties is now being grown, generally with little knowledge of their true yield potential, it was decided to carry out at Mylnefield a series of performance trials of the varieties at present most popular. The first of such trials, now in progress, contains seven varieties widely grown in the Clyde Valley and two recent introductions from the Glasshouse Crops Research Institute. Particular attention has been paid to the occurrence of 'rogues': it was found at the seedling stage that the two G.C.R.I. varieties contained 59% and 17% of rogue (or 'half-rogue') plants, E.S.1. 55%, and Ware Cross 17%. Four of the popular commercial varieties, including Moneymaker, which do not stem directly from research stations, were free from rogues. The occurrence of rogues in tomatoes is usually attributed to the activity of plasmagenes, although other genetical explanations are feasible.

The seedling variability of the nine varieties was estimated from height measurements taken 34 days after pricking out. The most variable were the two G.C.R.I. varieties, with coefficients of variation of 25% and 18%. By contrast, the popular Moneymaker and Dutch Victory were highly uniform, with coefficients of only 2%.

It is hoped that these trials will provide detailed information on such characteristics as times of ripening, yields, grading and disease resistance.

Selection for an Early, High-Yielding Variety Adapted to Scottish Conditions

An F_2 population of 965 seedlings was raised from seed obtained by selfing the F_1 hybrid Ware Cross (=E.S.1. x Potentate), and an initial selection was made of the plants which were earliest to flower. These were then reduced in number by the elimination of those which produced furrowed, fasciated or cracked fruits, and a final selection was made by retaining only those which bore high-yielding first trusses of uniform fruits. In this way three plants were finally chosen as the F_3 parents. The best selection had many rounded fruits of medium size on the first truss, the second choice had somewhat broader and longer fruits, while the third selection had broad and flatter fruits. The F_3 progenies of these selections, now growing, consist of populations of 504, 180 and 185 seedlings respectively. As the widest segregation will have occurred in the F_2 generation, when a highly critical selection (0·3%) was applied, these three lines are expected to breed almost true; but further selection will be necessary for at least two more generations before any line can be included in a variety trial.

Polygenic Selection within Inbred Lines

A purely genetical study was initiated in the hope of supporting K. Mather's hypothesis that the stability of homozygous inbred lines can ultimately be broken down by intensive polygenic selection based on a quantitative character. Three cultivated varieties of tomato, Moneymaker, Kondine Red and Potential, were used and selection was made of those seedlings in which the cotyledons differed in number from the normal two: such plants, with 1, 3 or 4 cotyledons or intermediate types, are called 'pleiocots.' When progenies from these plants were compared with progenies from normal controls, it was found that the proportions of pleiocots produced by all the parents were similar. This lack of response to selection was not unexpected, because it is known from selection experiments with inbred *Drosophila* that polygenic selection appears at first to be ineffectual: only after several generations of selection do the cryptic recombinations of chromosomes appear. The selection for pleiocotyly will therefore be continued. (G. Haskell.)

PUBLICATIONS

Book

HASKELL, G. (1961). *Practical Heredity with Drosophila.* 140 pp. Edinburgh: Oliver & Boyd, 10/6d.
(A guide to the genetical study and manipulation of the fruit-fly, *D. melanogaster*.)

Research Papers

HASKELL, G. (1961). Some recent advances in Rubus genetics. *Sci. Progr.*, **49,** 36-51.
(Discusses fruit and seed anatomy, germination, paucity of genes, and the distribution of instability of chromosome numbers. The use of apomixis to produce virus-free raspberry stocks is suggested. Present-day polyploid apomicts may carry the original diploid genomes 'genetically imprisoned' since the last glaciation.)

HASKELL, G. (1961). Genetics and the distribution of British *Rubi*. *Genetica*, **32,** 1-16.
(A detailed, illustrated account of the subject outlined in the 1959-60 Annual Report.)

HASKELL, G., and TUN, N. N. (1961). Development sequence of chromosome number in a cytologically unstable Rubus hybrid. *Genetical Research*, **2,** 10-24.
(Serial cytological observations on root-tips of an aberrant seedling revealed a range of 9 to 46 chromosomes per cell: the mode was $2n=35$. A stipule cell had $2n=39$. Satellite study indicated that not always were the same chromosomes eliminated. There was a correlation between chromosome numbers and corresponding cell sizes within the aneuploid series: this may be associated with incremental changes of DNA. The cause of the instability was not established. Changes in chromosome number of other Rubi may have had a somatic origin.)

Reviews and Abstracts

HASKELL, G. (1960). The 2 Rs of plant breeding. *Nature, Lond.*, **187,** p. 184.
(Review of 'Rubus and Ribes—a Survey' by R. L. Knight and E. Keep.)

HASKELL, G. (1960). Phenoploidy and the distribution of European and British blackberries (*Rubus fruticosus* agg.). *Heredity*, **14,** p. 22. (Abs.)
(Paper read to The Genetical Society, at a meeting at Queen's College, Dundee.)

HASKELL, G. (1960). Chromosome, genes and plant ecology. *Bot. Soc. Edinburgh Notes*, **125,** p. 2. (Abs.)
(Paper read to The Botanical Society of Edinburgh.)

HASKELL, G., and TUN, N. N. (1961). Chromosome variation within a Rubus plant. *Heredity*, **15,** 454-5. (Abs.)
(Paper read to The Genetical Society, at a meeting at University College, London.)

VIROLOGY

C. H. Cadman

Work this year was interrupted by preparations for the Symposium on soil-borne viruses held at the Institute in July, and by a series of visits abroad by members of staff. Each of these is referred to elsewhere in this Report.

SOIL-BORNE VIRUSES

The general discussions of results and ideas at the Symposium, and the intense activity, both here and elsewhere, that preceded it, make it easier to appraise the problems posed by soil-borne viruses. Root-feeding nematodes act as vectors of most of the soil-borne viruses so far found in Britain, Europe and North America but may not be the only kind of agent in soils concerned with virus transmission. The patterns of distribution and spread of the nematode-transmitted viruses reflect the wide feeding habits and ecological preferences of their vectors. All have wide host and territorial ranges but are locally distributed. Although the local outbreaks of diseases they cause in crops are often spectacular, these are generally of less consequence than the results which follow the vegetative propagation and distribution of plants that have been grown on infected land. The development of methods of controlling these diseases needs knowledge of the ecology both of the viruses and of the nematodes, and this can only slowly be acquired.

Viruses with Nematodes as Vectors

Identification and Properties

Arabis mosaic virus seems both the commonest and the most widespread of this group of viruses. Privet (*Ligustrum ovalifolium* and *L. angustifolium*) is a recent addition to the host range of this and other nematode-transmitted viruses. Out of 30 samples collected at random from gardens in Scotland, England, the Netherlands and Germany, arabis mosaic virus was present in 20, tomato black ring virus in 6, and tobacco rattle virus in 4. Indeed, no plants free from virus infection have yet been found. All of 6 samples from the Netherlands contained arabis mosaic virus although the virus has not yet been found in soils there. Also for the first time, this virus was found in Western Germany infecting strawberries of the varieties Oberschliesen and Senga Sengana near Heidelberg. Though more virulent than most, the German isolate, like other continental ones, is closely related serologically to British isolates of arabis mosaic virus. *Xiphinema diversicaudatum* (det. J. B. Goodey) was present in soil from the disease outbreak but not in similar soil nearby.

The viruses isolated last year from diseased grape vines sent from California, France and Switzerland were shown to be strains of arabis mosaic virus, closely related to each other but rather distantly to the type strain of the virus. The Californian and one of the French isolates were transmitted to healthy grape vines by grafting to systemically infected plants of *Chenopodium amaranticolor*. It now seems likely that fanleaf disease of grape

vine is caused by strains of arabis mosaic virus, and that such strains are commonly present in plants which show symptoms recognized as panachure and yellow mosaic. Possibly these symptoms are caused by other viruses which, unlike arabis mosaic virus, are not readily transmissible mechanically from grape vine to herbaceous hosts.

A virus isolated by Dr. J. A. Milbrath from Napoleon (Royal Anne) cherry affected by a severe disease of the rasp-leaf type at Eola Hills, Oregon, was identified with tomato ringspot virus. Another virus, which shares many features with but seems unrelated to tomato ringspot virus, was isolated from diseased blueberry (*Vaccinium corymbosum* L.) plants from New Jersey. Its properties and relationships are being studied in collaboration with American workers at Rutgers University. (C. H. Cadman, R. M. Lister.)

Infective virus particles are only one of several products of infection of plants by arabis mosaic virus. By means of centrifugation in density gradients, three kinds of particles, differing in sedimentation rates and in reaction to phosphotungstic acid, have been isolated. All three kinds of particle seem antigenically the same and look similar in the electron microscope, but infectivity is associated mainly with the heaviest particles. There is now much evidence to show that the particle of arabis mosaic virus consists of an outer shell, made up of numerous small sub-units, and an inner core of relatively few larger units. (C. H. Cadman, J. Cathro.)

A different form of aberrant virus synthesis seems characteristic of tobacco rattle virus. Variants which multiply well in plants (M types) and are readily sap-transmissible invariably give rise to others (NM types) which seem to multiply poorly, are difficult to transmit mechanically, yet produce severe symptoms in potato and other plants. Sap from plants infected with M types always contains characteristic rod-shaped particles of differing lengths, whereas that from plants infected with NM types usually contains no such particles. However, the tissues of NM-infected plants contain much potential infectivity which is released when extracts from them are made with the aid of phenol. Potential infectivity seems associated with nucleic acid contained in a sub-cellular component, possibly the nucleus. This discovery may have rather wide implications, and it is certainly the first instance of severe diseases in plants caused by nucleic acid unassociated with recognizable virus particles. (C. H. Cadman.)

Transmission and Dissemination

Experiments with soil samples from fields in eastern Scotland where outbreaks of tomato black ring and raspberry ringspot viruses occurred in raspberry and strawberry crops, showed that the presence of virus was closely correlated with that of *Longidorus elongatus*, an ecto-parasitic nematode. In pot experiments, *L. elongatus* hand-picked from virus-containing soil rings. Uninfective *L. elongatus* acquired the virus from artificially infected cucumber plants and subsequently transmitted it to turnip seedlings. The transmitted tomato black ring virus to sugar beet, turnip and spinach seed- numbers of transmissions obtained in the laboratory were fewer than might have been expected from the infectivity of the soil from which the nematodes were extracted, and the reasons for this discrepancy are being sought. There

is much evidence to suggest that *L. elongatus* is also a vector of raspberry ringspot virus, but this has not yet been confirmed. (W. P. Mowat, C. E. Taylor.)

Establishment of the viruses in soils results only when their nematode vectors are present together with a source of infection. Because the viruses themselves are transmitted through the seeds of the many kinds of weeds and crop plants they infect, infected seeds may serve both as a means of dissemination of the viruses and as a reservoir of infection in soils. Most information has been obtained for tomato black ring virus, for which there is evidence of seed transmission in 19 plant species in 12 families; arabis mosaic virus was seed-borne in 7 species, representing 6 families, and raspberry ringspot virus in 5 species, representing 4 families. The proportion of virus-containing seeds produced is fairly constant for any particular virus-host combination, and may be high; approximately 50% of the progeny of *Stellaria media* plants containing arabis mosaic, raspberry ringspot, or tomato black ring viruses were infected. In other tests, cherry leaf roll virus was transmitted through 100% of seeds of soybean (*Soja max*), and tobacco rattle virus was detected in 2% of progeny of infected plants of *Capsella bursa-pastoris*. Crop plants in which seed transmission has been demonstrated include sugar beet, strawberry and soybean. Indeed, these viruses are seed-borne in a sufficiently wide range of plants to suggest that they behave similarly in many other species. A striking feature is the absence, in most infected seedlings, of any of the symptoms which typically follow artificial inoculation. The numbers of infected seeds in air-dried soils from various disease outbreaks varied widely. The most commonly infected species was *Stellaria media*: in some soils as many as 50% of the seedlings of this species tested were infected, while in others no infected seedlings were found. Reasons for these differences are being sought.

Arabis mosaic, raspberry ringspot and tomato black ring viruses were detected in pollen from plants that contained them, and experiments are in progress to find if the viruses pass through pollen to the seed. (R. M. Lister, A. F. Murant.)

Control

A field experiment was begun at Coupar Angus, Perthshire, to see if chemical treatments would decrease the infectivity of a soil containing raspberry ringspot and tomato black ring viruses. Vapam, Thiram, pentachloronitrobenzene, DD and DD plus solubilized xylenol were applied to the soil in September. Nematode counts made before and after treatment showed that the numbers of *Longidorus elongatus* had decreased considerably in plots treated with DD and to a lesser extent in those that received Vapam. The experimental area has since been planted with strawberries to assess the infectivity of the soil, and nematode counts are being made at intervals.

On land containing tomato black ring virus, plots which in 1959 had been cropped with oats, potatoes or sugar beet, left to grow weeds, or kept bare-fallowed were sown in March 1960 with sugar beet, and samples of the plants were tested for virus in June. Significantly fewer sugar beet plants were infected when grown on plots where weed growth had been suppressed in

1959, whether by bare fallow, potatoes, or sugar beet. This experiment is being repeated. (J. Chambers, W. P. Mowat, A. F. Murant, C. E. Taylor.)

Other Soil-borne Viruses

There are still other viruses that survive and spread in soils in some unknown way. In Britain the commonest of these are viruses of the tobacco-necrosis type. There is no indication of the nature of the agent, if one exists, concerned in transmission. Claims that a fungus, *Olpidium brassicae*, is associated with transmission were not confirmed in laboratory experiments, but equally these have so far given no unequivocal evidence of virus transmission under sterile conditions. (W. P. Mowat.)

APHID-BORNE VIRUSES

Spread of Viruses in Strawberry

Field investigations show that populations of the strawberry aphid (*Pentatrichopus fragaefolii*) in eastern Scotland usually reach their peak, and produce the greatest numbers of winged forms, in autumn. Field experiments with *Fragaria vesca* have already shown that this is also the time when most spread of aphid-borne viruses occurs. Although these viruses commonly spread from sources of infection within or immediately adjacent to cultivated strawberry crops, there is little or no evidence of their spread over a distance. Plots of Royal Sovereign strawberry planted in 1957 in sites remote from sources of infection were still free from visible symptoms of virus infection in October 1960, but spread of viruses causing visible symptoms had occurred in other plots of this variety that contained infected Cambridge Favourite plants. (R. M. Lister, C. E. Taylor.)

Mechanical Transmission of Viruses from Raspberry

Latent viruses that occur in apparently healthy plants of Lloyd George, Malling Exploit, Malling Landmark, Malling Promise and Norfolk Giant raspberry were transmitted by means of aphids (*Amphorophora rubi*) to black raspberry (*Rubus occidentalis*) seedlings, and from these to herbaceous plants by mechanical inoculation of sap. Although each of the virus isolates infected systemically and produced distinctive symptoms in *Chenopodium amaranticolor*, *C. quinoa*, *Petunia hybrida* and *Datura stramonium*, attempts to transmit them back to black raspberry and to obtain information on their properties failed. Apparently the viruses reach only low concentrations in both raspberry and herbaceous test plants. (C. H. Cadman.)

Virus-free Raspberry Stocks

Usually we have to meet complaints that the supplies of raspberry canes raised from virus-free parent plants are inadequate. This year there was a surplus of all varieties, and requests for canes of Malling Jewel, the most popular variety, totalled only one-fifth of the amount asked for in 1960. The totals of first-size canes of each variety distributed were: Lloyd George (SH_1/60), 3,000; Malling Promise (SH_2/60), 3,600; Norfolk Giant (SH_4/60), 3,100; Malling Enterprise (SH_5/60), 1,000; Malling Jewel (SH_6/60), 14,500; Burnetholm Seedling (SH_7/60), 2,000; Malling Landmark (SH_8/60), 1,000.

Repeated attempts to produce virus-free plants of Malling Seedling M have so far failed. (J. Chambers.)

OTHER VIRUSES

Evidence from a field experiment suggests that bushy dwarf, a virus which is now widespread in commercial stocks of Lloyd George raspberry and which is mechanically transmissible to herbaceous hosts, is spread by insects, possibly *Thrips* spp. Although this virus produces severe effects in Lloyd George and is carried without symptoms by Norfolk Giant, most other commercial raspberry varieties seem immune from infection. (C. H. Cadman.)

Work has begun on viruses affecting Gladiolus. (J. Chambers.)

PUBLICATIONS

Research Papers

Cadman, C. H. (1960). Studies on the relationship between soil-borne viruses of the ringspot type occurring in Britain and continental Europe. *Virology*, **11**, 653-64.

(Three soil-borne viruses of the ringspot type (tomato black ring, raspberry ringspot and raspberry yellow dwarf) have been described from Britain. This paper reports the results of tests made to see if other viruses found in Britain and continental Europe and transmitted in an unknown manner were related to any of these three viruses.

Plant protection and serological tests showed that raspberry yellow dwarf is closely related to, and should be considered a strain of, arabis mosaic virus. Arabis mosaic was also found infecting wild elder and cherry in Britain, horseradish in Denmark and rhubarb in Germany. Raspberry ringspot virus occurred in cherry trees affected by Pfeffinger disease in Germany and Switzerland.

No common antigens were detected in preparations of raspberry ringspot and tomato black ring viruses, although the two viruses often occur together in soils. As with tomato black ring virus, there was much evidence of geographical variation between isolates of raspberry ringspot virus from Scotland, England, and continental Europe, but isolates of arabis mosaic virus from different countries were scarcely distinguishable.)

Cadman, C. H., and Chambers, J. (1960). Factors affecting the spread of aphid-borne viruses in potato in eastern Scotland. III. Effects of planting date, roguing and age of crop on the spread of potato leaf-roll and Y viruses. *Ann. appl. Biol.*, **48**, 729-38.

(This paper reports the results of a 5-year study of the spread of potato leaf-roll and Y viruses in experimental and field crops of potato in eastern Scotland. Contrary to common belief, both viruses spread in Scottish 'seed' crops, but the extent to which they do so is determined by the presence of sources of infection within crops and the susceptibility of potato plants to infection at the time when potato aphids (*Myzus persicae*) arrive on crops. There was no evidence of spread of either virus over long distances, but much to show that spread occurred in late June and early July from infected plants within crops. Potato plants are most susceptible to infection during the first 6 weeks after emergence, and localities that are best for high-grade seed production are those where potato crops become colonized by aphids late in the growing season.)

Cadman, C. H., (Dias, H. F., and Harrison, B. D.) (1960). Sap-transmissible viruses associated with diseases of grape vines in Europe and North America. *Nature, Lond.*, **187**, 577-79.

(Two groups of virus diseases of grape vines, court-noué and panachure, have been known for many years and occur widely in European vineyards. Similar diseases, known as fanleaf and yellow mosaic respectively, occur in California and are contracted from soil. The virus that causes fanleaf disease is transmitted by a nematode, *Xiphinema index*. Like other soil-borne viruses that occur in Europe and have nematodes as vectors, fanleaf virus was readily transmitted to herbaceous hosts by mechanical inoculation of sap from Californian vines that had been infected by means of nematodes. A similar virus was isolated from diseased grape vines from France, Portugal

and Switzerland. All the viruses isolated from grape vine were closely related serologically to each other and more distantly to arabis mosaic, a virus that is transmitted by another species of *Xiphinema*, *X. diversicaudatum*. No such viruses were isolated from healthy plants of grape vine. The Californian fanleaf virus was transmitted back to grape vine by grafting to infected *Chenopodium amaranticolor*. The results provide a new approach to the study of the relationship between the viruses associated with grape vine diseases.)

Cadman, C. H., and Lister, R. M. (1961). Relationship between tomato ringspot and peach yellow bud mosaic viruses. *Phytopathology*, **51,** 29-31.

(Peach yellow bud mosaic and tomato ringspot viruses seem to occur only in North America, but they have many properties in common with each other and with soil-borne viruses of the ringspot type that occur in Europe. Plant-protection and serological tests showed that peach yellow bud mosaic virus, which occurs in California and has a nematode as a vector, is closely related to tomato ringspot, a virus that is widespread in eastern United States and whose mode of spread was unknown.)

Chambers, J. (1961). The production and maintenance of virus-free raspberry plants. *J. hort. Sci.*, **36,** 48-54.

(Exposure for 2-3 weeks at 35°C has been used successfully to free plants of most of the present commercial varieties of raspberry from infection by aphid-borne viruses. The treatment has limitations, because the viruses differ in ability to survive and multiply in plants at high temperature. The techniques of producing and propagating virus-free plants are described.)

(Harrison, B. D.,) Mowat, W. P., and Taylor, C. E. (1961). Transmission of a strain of tomato black ring virus by *Longidorus elongatus* (Nematoda). *Virology*, **14,** 480-85.

(This paper describes experiments which led to the conclusion that the nematode *Longidorus elongatus* (de Man) is a vector of the beet ringspot (Scottish) strain of tomato black ring virus. *L. elongatus* hand-picked from virus-containing field soil transmitted the virus to sugar beet, turnip and spinach seedlings. Non-infective *L. elongatus* acquired and subsequently transmitted the virus from infected cucumber and potato plants. When adults and larvae were used separately, only larvae transmitted. A previously undescribed species of *Longidorus*, closely related to *L. elongatus*, has also been shown to be a vector of the lettuce ringspot (English) strain of tomato black ring virus.)

General Papers

Cadman, C. H. (1961). Soil-borne viruses in fruit trees. *Proc. 4th Symposium on Virus Diseases of Fruit Trees in Europe*, Copenhagen, 1960. (In press.)

Cadman, C. H., and Lister, R. M. (1961). Some aspects of recent work on soil-borne viruses. *Proc. 4th Symposium on Potato Virus Diseases, Brunswick*, 1960, 17-21.

Chambers, J. (1960). High health status nursery stock: Scotland as a potential producer. *Scot. Agric.*, **40,** 94-47.

MYCOLOGY

A. R. Wilson

GREY MOULD OF SOFT FRUIT

Autecology of Botrytis cinerea

The somewhat cool, dull and showery picking season of 1960 enabled several novel aspects of the effects of various climatic factors on spore dispersal to be observed. Records from a Hirst spore trap in a raspberry plantation showed that the typical late-morning and evening peaks of dispersal, previously reported, were frequently absent. Instead, there was generally a widely fluctuating spore release throughout the day, resulting, by previous years' standards, in only moderate concentrations of spores in the air. This pattern appeared to be related to low night temperatures, which retard sporulation, to infrequent deposition of dew, and to only small daytime fluctuations in relative humidity, which generally remained above the optimum range (65-85%) for the operation of the hygroscopic spore release mechanism. Even at these higher relative humidities, however, small fluctuations of 2-5% R.H. were apparently enough to maintain a moderate spore inoculum in the air. Spectacular rises in spore concentration in these conditions were coincident with the relatively frequent rain showers.

The release of spores by mechanical shock has been observed in the laboratory, and further experiments have confirmed that raindrops can disperse spores from dry and damp masses in very large numbers. This is achieved in two ways: by the scattering of single spores, apparently on an air shock wave, and in splash droplets, of a wide size range, completely coated with spores, none of which are wetted sufficiently to be suspended within the drop. The single dry spores are dispersed in air currents and the spore-coated droplets travel for twenty or more centimetres, sometimes with sufficient force to form secondary droplets on landing. Such spore-coated droplets are remarkably stable and can be manipulated with forceps. When the water drop dries out, the spore coating remains unbroken but invaginates to form a compact mass of spores. Laboratory observations suggest that hygroscopic movements of conidiophores do not eject spores into the air but rather dislodge them from their extremely fine attachments to the conidiophores, after which they lie in a loose mass to be dispersed by wind, rain or other means.

A wind tunnel has been constructed for further examination of the effect of these and other factors on spore release and dispersal.

A detailed examination was made of the initiation and spread of grey mould in a raspberry plantation to obtain information on the effect of wind direction, combined with that of row orientation, on the movement of airborne spores. This was done in a rectangular plot, 60×44 yd. in extent, planted with alternate rows of Malling Exploit and Norfolk Giant which were 6 ft. apart and

aligned in a north-south direction. The area lay near the north-west corner of a block of about nine acres of raspberries.

Grey mould first appeared on isolated berries distributed at random throughout the plantation, every such primary focus of infection apparently resulting from spores germinating in water held between the calyx and a ripening berry. Following this initial infection, the conditions for sporulation, spore dispersal and infection remained generally good for several days, with the wind predominantly from the east, the direction in which there was a large area of raspberries in the immediate vicinity. At this stage the disease affected 3·5% of the ripe fruit, but there was still no significant variation in its distribution within the plot. For most of the remainder of the picking season the wind was predominantly from the south-west, a direction clear of soft fruit for a considerable distance, but for a short period at the end of the season the wind was mainly south-easterly, again a direction in which there were raspberries. The overall results of the picking season showed that there was significantly more grey mould in the western and southern areas of the plot. Such a distribution cannot be explained simply in terms of wind dispersal of spores: other factors are obviously involved.

A comparison of the distribution of the disease on the two sides of the rows of this plot showed that the percentages of ripe fruit infected on the west and east sides respectively were 13·4 and 8·2: this difference was not significant at $P < 0{\cdot}05$ but was significant at $P < 0{\cdot}1$. Corresponding figures for infected plugs were 18·0% (west) and 19·0% (east), and for ripe fruit and plugs combined, 20·2% (west) and 16·7% (east). Neither of these differences was significant at either level. It was thought that insolation might have tended to dry surface films of water more rapidly on the east sides of the rows, with a consequent lower rate of infection from spore germ-tubes. This hypothesis was confirmed by observation, and it was also noted that fruit directly exposed to sunlight rapidly attained internal temperatures some 3-6°C higher than that of shaded fruit. Interaction effects between wind direction and row orientation and spacing might also be expected to influence the rate of evaporation of surface moisture films, but this has not yet been shown.

Similar observations were made in north-south rows of strawberries (var. Talisman) grown as spaced plants at 36 in. × 18 in. While no significant differences were found between the total amounts of fruit rotting along the east and west sides of the rows and centrally within the inter-plant spaces, the west sides showed a significantly greater loss than the east sides as a result of the infection of berries at the calyx end. Insolation and wind effects on the drying out of corolla debris may have been concerned in this difference. No such differences associated with position occurred in respect of fruit rotted by infection beginning on the sides or at the distal ends of berries through contact with adhering debris, or by infection through contact with berries already rotting. Of the total infections recorded, 64·0% occurred from fragments of straw, petals or other organic debris adhering to the side or the distal end; 17·4% from infection at the calyx end; 17·2% from contact with rotten berries, and only 1·4% from the germination of spores in water on the side or at the distal end. These figures emphasize the importance of plantation hygiene, including the timely removal of infected berries.

Control

With the increasing reluctance of food processors to accept fruit treated with the best available fungicides, namely captan and TMTD, more attention has been paid to control measures based on the modification of plantation management practices, particularly in the case of strawberries.

Since a high proportion of fruit infection in strawberries originates from adhering infested debris, attempts were made in plots of the variety Talisman to modify cultural practice in order to reduce the quantity of such material brought into contact with the fruit. This was done in three main ways: (i) by removing as much debris as possible by post-harvest mowing of the crowns and raking off the cut material; (ii) by screening the fruit from the soil and from fragments of straw left from the previous season, using for this purpose either wet-strength paper[1] treated with a persistent fungicide[2], or black polythene sheet[3], as substitutes for straw; and (iii) by impregnating the normal straw application with a persistent fungicide[2]. Mowing the crowns and removing the debris after harvest has the added advantage of reducing the humidity below the leaf canopy during the following season, so that conditions for the mycelial growth and sporulation of *B. cinerea* are less favourable.

Counts showed that each of the treatments mentioned resulted in a lower percentage of fruit infection than occurred on the control plots, but these differences were not significant ($P < 0{\cdot}05$), probably because plot size and replications were inadequate owing to lack of space.

Although as much debris as possible was raked from the autumn-mown plots, large amounts still remained in the crowns. Post-harvest burning would be more effective than mowing in this respect, but it was not practicable in 1960 and would rarely be so under Scottish conditions.

There was no evidence that any of the treatments differentially affected the incidence of the various types of infection listed in the foregoing section. This suggests that under the conditions of the experiment the effect of autumn mowing was to modify the microclimate, or the physiology of the host plant, rather than to reduce the debris inoculum.

The new fungicide Allisan[4] gave approximately the same degree of control as captan. Neither appreciably altered the relative amounts of the different types of infection.

The relative failure of fungicide programmes to reduce both infection from organic debris and infection at the calyx end of the fruit largely accounts for the disappointing results in overall control of the disease by this means. Since these particular fungicides are known to be reasonably effective against *B. cinerea* in other crops, it is suggested that either their persistence or the technique of their application is at fault. There is an inherent difficulty in maintaining an adequate cover on the rapidly expanding surfaces of soft fruit

[1]Supplied by Cresco Ltd.

[2]Copper-8-quinolinate (Cunilate 4520) supplied by Cuprinol Ltd.

[3]Supplied by British Cellophane Ltd.

[4]A dichlornitroaniline formulation supplied by Boots Pure Drug Co. Ltd. Insufficient information on the toxicity of this material is available at present to recommend its use on fruit.

as well as in protecting inflorescences at all stages of development from buds to ripe fruit. Further, the fungicides which can be tolerated on food are unlikely to eradicate the fungus from debris.

The fungicides captan, Allisan and griseofulvin oxime[1] were also applied to raspberries (var. Malling Exploit), each three times at 10-day intervals before picking. In another series of treatments the same materials, together with a new analogue of griseofulvin[1], were applied only during the picking season, immediately after each pick. No significant control ($P < 0{\cdot}05$) was achieved by any of the treatments, but significant increases of yield followed the captan and Allisan treatments. There was no evidence that application of fungicides during the picking season gave better control than pre-picking applications.

Varietal Susceptibility

Fruit extracts from six raspberry and eight strawberry varieties, prepared in various ways from fruit stored by drying and by freezing, were used as liquid and agar culture media for the growth of *B. cinerea*. In no case was a correlation established between growth rates in these somewhat crude extracts and susceptibility as determined by disease incidence figures.

To obtain information on the possible effect of plant habit on the incidence of grey mould, plants of strawberry (var. Talisman) and raspberry (var. Malling Exploit) were treated in various ways to simulate varieties of more open habit, i.e. having the berries more exposed. It was assumed that any chemical resistance mechanism of the fruit would remain unaltered. The strawberries were treated either by removing a proportion of the leaves to expose the berries or by tying the leaves into a central bunch raised well above the fruit. In one treatment applied to the raspberries leaves were removed from the fruit clusters, and in another about 40% of the berries were removed so as to prevent the spread of *B. cinerea* from berry to berry by contact. All the treatments were applied shortly before picking, and the desired effects persisted well throughout the picking season. In Malling Exploit raspberry a slight decrease in the incidence of grey mould was associated with each of the treatments, but the differences were not significant. In Talisman strawberry, the tying of the leaves into a bunch above the fruit resulted in significantly more grey mould than was present in the control. This latter result, which was unexpected in view of the known optimum conditions for fruit infection, has not been satisfactorily explained. The results with raspberry suggest that varieties with little or no foliage around the fruit, or with long pedicels to hold the fruit apart, may have some advantage in grey mould escape, but it is not possible from this experiment to suggest similar effects in strawberries. (W. R. Jarvis.)

GREY MOULD OF TOMATO

Observation and experimental results suggest that little progress can be made in the study of this disease until more information is obtained on physiological factors affecting the susceptibility of plants to infection. Work is now being concentrated on this aspect of the problem. (A. R. Wilson.)

[1]Supplied by the Murphy Chemical Co. Ltd.

DIE-BACK OF RASPBERRY

When a plantation of Malling Promise which had shown severe die-back symptoms during the spring and early summer of 1960 was examined in August, the young canes showed discoloured and slightly sunken areas which were unlike the lesions of cane spot, spur blight or cane blight. In these areas the wood and pith were discoloured and water-soaked, and the discoloration was evidently spreading in all directions in the pith. Hyphae were present in all the affected tissues, and isolations yielded a small number of fungi which included *Didymella applanata*, *Elsinoe veneta* and, more frequently, a species of *Coryneopsis*.

As the canes ripened the sunken areas became less obvious, but in the spring of 1961 there was some indication that where die-back symptoms were present these lesions had extended to girdle the stem, although this could rarely be seen without removal of the bark. Isolations at this time yielded an even smaller range of fungi, about one-half of the isolates being a species of *Coryneopsis*. The identity of this species is not yet fully established, but it has characters both of *C. microsticta* Grove and of *C. rubi* Grove. Pathogenicity experiments are in progress with this and other fungi isolated from stem lesions.

Cases of die-back of raspberries in waterlogged soils were again observed, but no connection with *Phytophthora cactorum* was established. Experiments on the effect of soil moisture on raspberry growth and on the pathogenicity of *P. cactorum* are in progress. (A. R. Wilson, W. R. Jarvis, T. G. Rubens[1].)

ANTHRACNOSE OF FRENCH BEAN

A limited but severe outbreak of anthracnose occurred on experimental plots at Mylnefield in late August 1960 (see p. 28). Isolates all proved to be the gamma biotype of *Colletotrichum lindemuthianum*. (A. R. Wilson, W. R. Jarvis.)

STORAGE OF POTATOES FOR PROCESSING

Trials in a store which contained about 1,200 tons of potatoes, and in which the roof and walls were insulated to give a U value of $< 0{\cdot}2$, showed that a minimum temperature of 50°F could be maintained throughout the winter in a 12-14 ft. stack without supplementary heating. Provision was made for the use of either bottom ventilation or air re-circulation, but the former was little used. It was found that the stack temperature differential, normally about 10°F, was virtually eliminated within a few days of starting forced-draught re-circulation at approximately 5 c.f.m./ton. In the absence of ventilation, the relative humidity of the store air remained in the region of 90% for long periods. This led to serious condensation in the roof insulation, showing that an effective vapour seal is essential under these conditions.

Intermittent treatment with nonanol vapour effectively controlled sprouting, which otherwise would have been considerable at this temperature. Some deterioration of the tubers occurred in parts of the store in early February. The cause of this has not been fully established, but there is little doubt that

[1]Edinburgh and East of Scotland College of Agriculture.

the high relative humidity was a contributory factor. Apart from some trouble associated with these areas of deterioration, potatoes (var. Record) taken at intervals from the store from November to early May produced crisps of uniformly high quality.

Forty 10 kg. samples of tubers, enclosed in nylon mesh bags and embedded in the stack, were used for the determination of weight loss. Preliminary examination of the results indicates that between late September and late February the loss of weight from sprouting was nil, and that the mean weight loss due to respiration and loss of water was about 4%. The presence of a small amount of rotting in most of the sample bags probably led to a recorded weight loss which was slightly above the true level. (A. R. Wilson[1].)

PUBLICATION

Research Paper

Jarvis, W. R. (1961). The growth of isolates of *Phytophthora fragariae* Hickman in the presence of various polyphenols. *Trans. Brit. mycol. Soc.*, **44**, 357-64.

(The growth of seven isolates from three pathogenic races of *P. fragariae* was indistinguishable in appearance, and barely distinguishable in rate, on most media normally used in the laboratory, but very great differences were evident when various polyphenols were added to a basal medium. Growth generally increased in the presence of gallic acid, protocatechuic acid, d-catechin, dl-tyrosine or chlorogenic acid each at a concentration of 0·001M. Pyrocatechol, cinnamic acid and p-cresol at the same concentration reduced or inhibited growth. The pattern of response of any particular isolate to a given set of polyphenols differed according to the method of culture; there were wide discrepancies between determinations of radial growth rate on solid media and of dry weight of mycelia from liquid media. There was no similarity in pattern of response to a given set of polyphenols between isolates of the same pathogenic race, or between isolates from different pathogenic races; all isolates behaved differently irrespective of source and pathogenicity.)

[1]In collaboration with the Agricultural Research Council's Ditton Laboratory.

WEST OF SCOTLAND UNIT (AUCHINCRUIVE)

R. D. Reid

STRAWBERRY BREEDING

Unlike the conditions which prevailed in many other parts of the country, the summer weather at Auchincruive in 1960 proved to be very satisfactory for strawberries. The fruit again ripened early—nearly two weeks ahead of the usual time—and there was consequently some difficulty in obtaining labour for picking. Nevertheless, an excellent crop was harvested, both the weight of fruit and the cash returns being the best for many years. The conditions were thus highly favourable for assessing the fruiting merits of the very large number of selections which were on trial, and it was possible to form an opinion on many selections which were fruiting only as small units. This is always a very difficult task when weather conditions are less favourable.

The season provided an opportunity to make a thorough assessment of a large number of selections from the 1952 crossings, which had been retained on trial from year to year, and finally to discard many whose value had been in doubt.

A particularly interesting batch of seedling selections included those which had fruited as single-plant units in 1959. Small units of some 125 of these were fruited in 1960 under cloches, where many gave an excellent performance which confirmed the earlier high opinion of their merits. From this group, nine were selected for intensive and extensive testing with a view to their further development if they continue to yield consistently. Units of them have been virus tested and runners have been sent to Mylnefield and to the National Fruit Trials at Brogdale for extension trials. In selecting these seedlings particular attention has been paid to their suitability for commercial purposes, including their flavour and ease of plugging. Arrangements are being made for the large-scale propagation of one or two of them if their good performance is maintained in 1961.

The 1961 season promises to be a most interesting one, for we now have on hand a very large number of selections which will be fruiting for the second or third time, and also single-plant units of more than 4,000 seedlings to fruit for the first time. Most of the latter are from crosses made in 1958 or 1959, and have twice been 'screened' for resistance to red core disease.

The 1959 crossings produced larger numbers of seedlings than usual. More than 16,000 were raised, and these have been tested, or are in process of being tested, for red core disease resistance in the field. Some will fruit in 1961, but the majority of those which survive the first two red core screenings will not fruit until 1962.

Seed from the 1960 crossings is also germinating very well, and there may again be a record number of seedlings. With the present enormous accumulation of seedlings undergoing red core and preliminary fruiting tests, some restriction in the size of families may have to be accepted if the work is to remain manageable.

Bench Testing

This method of testing for resistance to red core has now been in use for eight seasons, during which time more than 54,000 seedlings have been tested. At the outset three batches were passed through the benches annually, but in the 1958-59 Report it was shown that whereas in the summer months 67% of seedlings tested remained uninfected, only 38-46% did so during the winter and spring months. In view of its relative inefficiency as illustrated by these figures, testing in summer was discontinued, and bench testing is now confined to the period from September to April. In the winter of 1960-61 the proportion of seedlings remaining uninfected was about 56% in the first batch tested (October to January), but only 23% in the second batch (February to April). This high efficiency in the second period was attributed to external conditions which permitted discontinuance of pipe heat for a short period at a critical stage. Although a low temperature seems essential for infection, some minimum amount of heat is necessary when working with such small seedlings.

The bench testing is a valuable means of eliminating at an early stage the most susceptible seedlings, but the final criterion for the seedlings that survive continues to be that of growing them in the open field in infected soil. Following the heavy rainfall in November and December of 1960, the winter incidence of red core became severe and field testing in consequence more effective.

Red Core Disease and Field Resistance

The original objective of the strawberry breeding work here was the production of varieties immune from the red core disease fungus, *Phytophthora fragariae*, but it becomes increasingly clear that the goal of complete immunity from all races of the pathogen is receding. The more critical work on specialized physiologic races is now largely a mycological project (see below), and until more precise knowledge is available of the inheritance of resistance to combinations of these races the applied breeding work is having to concentrate largely on what is termed 'field resistance.' This was discussed in some detail in the 1959-60 Report.

The value of field resistance is difficult to assess because of the time factor. We now have some clones which, although known to contain root infection, have continued to show entirely satisfactory growth even when grown under conditions favourable for the disease and propagated vegetatively for from six to nine years. There is little doubt that some of these clones possess 'survival value' to a very high degree. In recent years they have been used extensively for crossing, and their influence should therefore become increasingly evident in newer selections. One of the most promising of these clones, 52AC18, was developed with a view to its possible release, but as a result of its fruiting in 1960 it was felt to be insufficiently productive to be introduced as a variety. This selection in particular has been much used in crossing. Another which has exhibited the highest degree of field resistance—including non-infection or, at the worst, only a minimum of root infection—is a hybrid from a cross made in 1953 between one of our own highly resistant selections and a plant of the species *Fragaria virginiana*. This clone un-

fortunately has the unsatisfactory fruit characters of the species parent, and extensive backcrossing has been necessary.

Selections which may be released during the next five years are unlikely to show field resistance as high as that of the clones mentioned above; but they should have a high survival value, including immunity from some specific races of *P. fragariae*, and a vigorous habit of growth which should enable them to grow and crop satisfactorily under all but the most adverse conditions. Their resistance to red core should be at least as effective as that of Cambridge Vigour or Talisman. It is hoped ultimately to combine the much more intense field resistance of the species-hybrids with the highly desirable fruiting characters developed in recent selections.

Other Diseases

In accordance with the policy of raising varieties with a high survival value to all diseases, as distinct from a specialized immunity from one disease, some of our basic breeding selections have been submitted to the virologists to be tested for their reactions to the group of soil-borne viruses now under intensive study at Mylnefield. A field trial has also been arranged in Kent to see if the high survival value exhibited by one particular selection also includes resistance to *Verticillium* wilt disease. It has been noted that the variety Redgauntlet possesses very high resistance to grey mould (*Botrytis cinerea*), and this will be taken into consideration in future selection work.

Fruiting Trials

The policy of fruiting selections under cloches in their second year has proved very valuable and is being extended. It gives an indication of suitability for early production, enables closer observation to be made where only very small units of plants are available, and avoids risk of loss from frost, birds and other external causes.

Trends in Seedling Expression

The following notes record some of the more interesting trends and features shown by recent seedling families.

June Yellows

Six years ago chlorotic variegation of the June Yellows type was very widespread among seedlings at Auchincruive. For the past two seasons the incidence of yellow seedlings has been very low, but observations in April 1961 (the time of writing) show an increase in the number of seedlings affected by this condition.

Mildew (*Sphaerotheca humuli*)

Wherever the variety Cambridge Vigour has been used in crossing there has been an increase in the incidence of mildew.

Fruit Characters

Recent selections have been showing marked improvement in fruit characters, including improved flavour and easier plugging. Some interesting and uncommon types are also segregating out, including seedlings with such characters as dark flesh and aromatic qualities, but it is difficult to decide how far such novelty features are likely to be of commercial value.

Effects of Interspecific Crossing

Use of the species *Fragaria virginiana* continues to show an influence on vigour of growth and general survival value, but the linkage of these characters with the typical small and soft fruit is difficult to break. Considerable improvement is now evident in the F_5 generation. The general influence of South American strains of the other octoploid species, *F. chiloensis*, has been to lower productivity, probably because of a difference in daylength adaptation, but some improvement can be expected now that the F_3 generation is coming into fruit. Use has also been made of some strains of this species from North America, which workers in U.S.A. have found to be immune from red core, and F_1 hybrids are now coming into fruit. Our own experience is that the clones received from North America are susceptible to the races of the pathogen present in our soils, but the performance of progenies obtained by outcrossing them with our own resistant material is being watched with interest. (R. D. Reid, A. M. Sutherland, K. C. McConnell.)

MYCOLOGICAL INVESTIGATIONS

Physiologic Races of Phytophthora fragariae

The pathogenicity of 36 isolates of *P. fragariae* obtained from a wide range of strawberry varieties and localities is now being studied. At the outset four varieties, Royal Sovereign, Huxley, Perle de Prague and Auchincruive Climax, were inoculated with each of these isolates, and although Royal Sovereign and Huxley proved susceptible to them all, the responses of the other two varieties differentiated four physiologic races. The range of indicator varieties has since been extended by the inclusion of Auchincruive No. 11, American Aberdeen, Redgauntlet and Talisman, and results now available for 29 of the isolates indicate the existence of 13 races of the pathogen. Each variety inoculated has proved to be susceptible to one or more of these races.

New Sources of Red Core Immunity

No further seed collections were acquired. Tests were continued on seedlings from one of the collections of *Fragaria chiloensis* received from Chile in 1957, using one race of *P. fragariae*. All of the 800 seedlings inoculated proved to be susceptible.

Inheritance of Immunity

Studies have been continued on the inheritance of immunity from or resistance to *P. fragariae* in a wide range of *Fragaria* material (see 1959-60 Report). Immunity is recorded in this work where there is a complete failure of infection, while resistance is recognized where the plant, though infected, is not destroyed. By selfing immune and resistant seedlings selected from successive generations and testing their progenies by inoculation with pure cultures of three different races of *P. fragariae*, further information has been obtained on the immunity and/or resistance potential of each of 18 commercial varieties, one intervarietal cross, three bred selections, *Fragaria chiloensis* from two sources, *F. ovalis* from two sources and *F. virginiana* from four sources. As a result of open pollination in the case of the three *Fragaria*

species, and of controlled selfing in the case of the remainder, all of these parents have produced progenies containing seedlings immune from at least one race of the fungus, but considerable variation was found in the proportions of susceptible and immune seedlings present in the F_1 progenies. In tests with the least pathogenic of the three fungal races used, the numbers of immune seedlings ranged from 0·2% in the F_1 of American Aberdeen x Royal Sovereign to 71% in the F_1 self of Auchincruive Climax. Only those F_1 seedlings which showed either resistance to or immunity from one or more races of fungus were selected for further selfing, and in the F_2 progenies the variation in the proportions of susceptible and immune seedlings has been less wide. The extremes so far obtained are 12% and 58% of immunes, produced by selfing F_1 seedlings from stocks of *F. virginiana* and Auchincruive No. 11 respectively. All these figures are based on families of at least 100 seedlings.

Some F_2 families derived from American Aberdeen and Auchincruive No. 11, and F_3 families from *F. chiloensis* (type ex Korea), have shown no segregation of susceptibles, but since the numbers of seedlings in these were small there is as yet no conclusive evidence that lines have been obtained which would breed true for immunity from even one race of *P. fragariae*.

The search continues for sources of resistance to or immunity from more than one race, and work is proceeding on 77 lines carrying immunity from at least two races. American Aberdeen, Auchincruive Climax, Cambridge Vigour, Little Scarlet and Auchincruive No. 11 together provided 41 of these lines, the remainder having been derived from *Fragaria ovalis* and *F. virginiana*. It is of interest to note that 24 of these lines were derived from two seed collections, one of *F. ovalis* and one of *F. virginiana*, produced by open pollination under conditions of natural habitat, where there was no possibility of cross-pollination by commercial strawberry varieties.

Thirty lines are now available which carry immunity from at least three races of *P. fragariae*, including the most pathogenic race available. American Aberdeen, Cambridge Vigour, Little Scarlet and Auchincruive No. 11 produced ten of these lines and the remainder were derived from *F. ovalis* and *F. virginiana*, 16 of them, again, from the isolated sources already mentioned. (I. G. Montgomerie.)

PUBLICATION

Reid, R. D. (1960). Breeding strawberries. *Bulletin de l'institut agronomique et des stations de recerches de Gembloux: série extraordinaire éditée à l'ocasion du centenaire de l'institut agronomique de l'état*: **2**, 988-93.

(This paper discusses general problems and objectives in present-day strawberry breeding, and describes the laboratory, glasshouse and field techniques used at Auchincruive in specialized breeding for resistance to red core disease.)

METEOROLOGICAL RECORDS, 1960

J. SUNDERLAND

The meteorological records from Mylnefield and Auchincruive for 1960 are summarized in the following tables. The values for Auchincruive have been taken from copies of the Monthly Weather Report, issued by the Meteorological Office.

MYLNEFIELD, 1960

Month	Temperature		Rainfall		Sunshine		Ground Frost
	Mean* °F	Deviation from average†	Inches	Deviation from average‡	Hours	Deviation from average†	Days
Jan.	36·9	−0·6	4·10	+2·17	47	− 3	24
Feb.	35·5	−3·0	2·41	+0·56	112	+36	23
Mar.	40·2	−1·0	2·11	+0·26	68	−37	4
Apr.	47·8	+3·0	2·15	+0·54	138	− 2	5
May	52·8	+3·4	1·85	+0·15	202	+36	1
June	57·7	+2·4	2·23	+0·54	216	+34	0
July	56·7	−2·3	2·76	+0·20	150	− 4	0
Aug.	56·8	−1·1	4·33	+1·06	154	+13	0
Sept.	53·6	−0·4	1·60	−0·40	125	+ 3	0
Oct.	49·5	+1·6	6·16	+3·56	42	−53	3
Nov.	41·1	−0·6	2·99	+0·67	66	+ 3	22
Dec.	35·8	−3·2	1·81	−0·71	44	+ 3	27
Year	47·0	−0·2	34·50	+8·60	1,364	+29	109

*Computed from daily mean of maximum and minimum temperatures at 09·00 G.M.T.

†Recorded at official Dundee meteorological station, 1921-1950.

‡Recorded at official Dundee meteorological station, 1881-1915.

AUCHINCRUIVE, 1960

Month	Mean Temperature (°F)	Rainfall (inches)	Sunshine (hours)	Ground Frost (days)
January	38·5	3·70	61	24
February	37·3	2·62	98	21
March	43·2	1·70	110	10
April	47·5	2·16	154	6
May	53·9	1·44	205	2
June	58·5	1·68	251	1
July	57·5	2·66	141	0
August	57·3	3·38	102	0
September	53·2	2·78	162	1
October	49·5	2·13	74	6
November	43·0	5·04	82	13
December	37·3	4·95	45	22
Year	48·1	34·24	1,485	106

SUMMARY OF WEATHER AT MYLNEFIELD

JANUARY

Snow fell during the second and third weeks. There was a gale on the 19th with snow drifting to a depth of 1-2 feet. Rainfall was high during the fourth week.

Highest max. 55°F on 1st; lowest min. 19°F on 21st)

FEBRUARY

There were several falls of snow (1-2 inches) during the third and fourth weeks, accompanied by low temperatures. The last three days were warmer, with fog and drizzle.

Highest max. 53°F on 29th; lowest min. 19°F on 19th)

MARCH

Slight showers of snow on the 8th and 9th were followed by a week of rain. The remainder of the month was generally cloudy and misty.

(Highest max. 53°F on 5th; lowest min. 27°F on 9th)

APRIL

Warmer but rather wet during the first two weeks. There was a gale on the 13th and showers of hail occurred on the 15th.

(Highest max. 61°F on 22nd; lowest min. 30°F on 17th)

MAY

A bright, warm month, but with heavy rain from the 11th to the 14th, including 1·47 inches on the 13th.

(Highest max. 68°F on 31st; lowest min. 32°F on 2nd)

JUNE

Sunny and warm. The recorded rainfall occurred between the 5th and the 15th, the remainder of the month being completely dry. There were thunderstorms on the 7th and 8th, accompanied by heavy rain.

Highest max. 77°F on 20th; lowest min. 44°F on 7th)

JULY

Cooler and dull, with the rainfall well distributed throughout the month. There were thunderstorms on the 13th and 17th.

(Highest max. 71°F on 24th; lowest min. 41°F on 2nd)

AUGUST

Rather wet, with the rainfall again well distributed. There were thunderstorms with heavy rain on the 18th and 22nd.

(Highest max. 76°F on 3rd; lowest min. 37°F on 14th)

SEPTEMBER

A cooler, drier month, often with rainy and bright days alternating.

(Highest max. 68°F on 10th; lowest min. 36°F on 21st)

OCTOBER

An exceptionally wet and sunless month, with more than an inch of rainfall on the 23rd and also on the 29th.

(Highest max. 61°F on 4th; lowest min. 34°F on 13th)

NOVEMBER

Cold and bright, with ground frosts of greater severity than is usual in November. Thunder was heard on the 9th and there were several days of fog.

(Highest max. 56°F on 30th; lowest min. 26°F on 8th)

DECEMBER

Cold, with continuous ground frost. There was a shower of hail on the 10th and a scattering of snow on the 12th.

(Highest max. 49°F on 25th; lowest min. 22°F on 15th)

SYMPOSIUM ON SOIL-BORNE VIRUSES

8-10 July, 1960

C. H. Cadman

By 1959, work on soil-borne plant viruses in several countries had reached a stage where an opportunity for representative workers to meet and exchange information and ideas seemed likely to serve a useful purpose. The proposal that a meeting, in the form of a symposium, be held in Scotland was welcomed, and received generous support from the Agricultural Research Council in the shape of funds to help defray the costs of such a meeting and of bringing participants from overseas. For three days, 8-10 July, the Institute was privileged to act as host to a stimulating conference in which workers from Britain, Europe, Japan and the United States took part. The occasion was certainly a memorable one and deserves recording for that reason alone. This is no more than a brief record, for it was agreed not to publish any detailed account of the proceedings. The programme reproduced below must suffice to indicate the scope of the Symposium. Too often, meetings of this kind are marred by the obligation to produce printed records which serve no useful purpose. There is no doubt that the ban on publication encouraged the informality and free exchange of information which made the occasion a success.

The conference was the first of its kind and included among its members workers representative of most aspects of research on soil-borne viruses. Developments in some lines of work had occurred rather rapidly immediately prior to the conference, and it was hoped that the meeting would aid the collation of recent information. At the same time, the programme was designed to air some older and less familiar problems to see if new information shed light on these, and to gain some perspective of the field of research in soil-borne viruses.

Altogether some thirty plant viruses are known which have some natural underground method of spread. They occur in many different countries: some cause serious diseases in particular localities, whereas others cause disease outbreaks of epidemic proportions over large areas. For about half of these viruses there is rather good evidence that soil-living agents are concerned in their transmission, but discovery of the nature and identity of these agents has, for the most part, presented a baffling problem. Although it might seem a simple matter to analyse infective soil and decide which of its biological constituents are likely to act as virus vectors, this is vastly more difficult than it sounds. This direct approach did in fact lead to the discovery in 1958, by Prof. W. B. Hewitt and his colleagues, of a nematode vector, *Xiphinema index*, for fanleaf, a soil-borne virus disease of grapevine in California: but not before a good deal of preliminary work had indicated that spread of the disease in the field was correlated with the presence of this particular nematode in the soil.

At first, there seemed little to connect fanleaf disease with the soil-borne virus diseases of raspberry, strawberry and other crops which have been studied at this Institute during the past five years. These are caused by arabis mosaic, raspberry ringspot and tomato black ring, viruses that are readily transmitted by mechanical inoculation of sap and infect a wide range of crop and weed plants. By contrast, fanleaf disease seemed restricted to grapevine, and all attempts to transmit virus mechanically from diseased vines to herbaceous plants had failed. In 1958, nematodes of the genus *Xiphinema* were found for the first time in Britain: in Kent associated with outbreaks of arabis mosaic virus in strawberry, and in Somerset associated with the same virus in white clover. Experiments at East Malling Research Station, Rothamsted Experimental Station and Mylnefield in 1959 showed that this nematode, *X. diversicaudatum*, was a vector of arabis mosaic virus, and this result stimulated a hunt for nematode vectors for the other soil-borne viruses which had been found in Britain and continental Europe. In the meantime the discovery was announced that *Xiphinema americanum* transmitted yellow bud mosaic virus of peach in California, and subsequent work in Scotland showed that this virus was a strain of tomato ringspot, a virus which occurs in many parts of N. America but whose mode of spread was formerly unknown. Early in 1960 it became clear that tomato black ring and raspberry ringspot viruses had nematodes as vectors, and it seemed likely that tobacco rattle, a soil-borne virus which had been known for many years in Europe, also had a nematode vector. In autumn 1959, sap-transmissible viruses were isolated from fanleaf-diseased grapevines sent to this Institute from Europe and California, and subsequent experiments here and at Rothamsted showed that these viruses were in fact strains of arabis mosaic virus. Thus the circle was complete.

The excitement generated by this series of discoveries is not difficult to recapture. They lent a unity of purpose to a major part of the programme of the Symposium. During the meeting, Dutch workers announced the discovery of a nematode vector, *Trichodorus pachydermus*, of tobacco rattle virus; Prof. Hewitt added vine yellow mosaic to the list of viruses transmitted by *Xiphinema* spp., and evidence that *Longidorus elongatus* transmits Scottish strains of tomato black ring virus was discussed. Thus, in the space of a few years, at least five different soil-borne viruses (arabis mosaic, raspberry ringspot, tomato black ring, tomato ringspot and tobacco rattle viruses) had been found to have nematodes as vectors.

Besides being nematode-transmitted, these viruses share many other properties. They infect a wide range of crop plants, causing serious diseases in some, and occur naturally in an even wider range of weed plants. Indeed, they seem essentially pathogens of wild plants. All the viruses have wide but discontinuous geographical distributions; where they occur they are usually restricted to patches in particular fields. Both the persistence and spread of the viruses in soils and their dissemination over long distances must be intimately bound up with the relationships between viruses, nematodes and host plants. This is an unexplored field and one certain to yield results of interest and of practical value in leading to an understanding of how best to control the viruses. The pattern of future work was indicated by several

of the contributions to the conference. Of more immediate use, perhaps, were the discussions, both public and private, on problems of experimental techniques.

The conclusion emerging was that nematode-transmitted viruses seem largely to be local nuisances. Their importance lies in their widespread and usually unsuspected occurence in soils, and in the fact that valuable stocks of plants can be ruined through the unwitting choice of infected land in which to propagate them. As economic problems, the diseases they cause are insignificant in comparison with the soil-borne wheat and oat mosaic diseases which occur over immense areas in eastern and central United States. These have been the subject of pioneer work by H. H. McKinney and his associates since the 1920's, and their method of spread is still unknown. Although some kind of soil-inhabiting organism seems concerned in their transmission, none has been identified. The published evidence permits doubt that these diseases are in fact caused by viruses; but this was dispelled by the able review given at the Symposium by Dr. W. H. Sill, and one could not help but be impressed both by the magnitude of the problem and by its baffling nature.

Somewhat the same criticism applied to tobacco stunt, a soil-borne disease which occurs in Japan and which is transmissible only by grafting and seems restricted to tobacco. Professor Z. Hidaka reviewed evidence which established the virus nature of this disease and described experiments which suggest that a fungus, *Olpidium brassicae*, is concerned in its transmission.

The idea that fungi might transmit soil-borne viruses has been proposed before, particularly with respect to the tobacco necrosis viruses (so-called because they produce necrotic lesions in inoculated tobacco leaves). These viruses have been known for some years and seem virtually ubiquitous in soils in Britain, Europe and N. America. They are of little economic importance because most remain localized in the roots of infected plants: others cause systemic diseases in beans, cucumber and tulips, and necrosis in potato tubers. The viruses are rather infectious and stable, properties which make their natural method of transmission difficult to investigate: this method is still unknown. Some of the information contributed by Dutch workers could be interpreted to indicate that some kind of agent is needed for transmission.

It seems odd that, of the enormous range of soil-living organisms, ectoparasitic nematodes should be the only ones so far found to transmit plant viruses. This could merely reflect the trend of recent work and perhaps the relatively small extent to which transmission of viruses through the soil has been investigated; but in fact, much painstaking search for vectors among other classes of soil organisms has so far been fruitless. Whilst none would deny the likelihood that viruses may spread through the soil in different ways, the discovery of new modes of transmission may require an effort of imagination as difficult to achieve as the solution of some of the technical problems of working with soil-living organisms. If interest in soil-borne viruses is maintained at its present level, many new developments may be expected. That some of the predictions made and ideas exchanged at the Symposium have since become fact is perhaps the best evidence of its usefulness.

In lighter vein, we tried to interpret the meaning of Symposium (with

drink) as literally as funds would allow. On the first evening, visitors and their wives were entertained privately by members of staff and afterwards at a reception at the Institute given by the Director and Mrs. Swarbrick. The following evening the members of the Symposium were generously entertained in the City Chambers by the Lord Provost and Magistrates of the City of Dundee. The Symposium concluded with visits to raspberry and strawberry plantations in Angus and Perthshire to see outbreaks of soil-borne virus diseases, and during this tour members were entertained to lunch at Blairgowrie by Mr. Graham Smedley. Much of the success of the meeting was due to the excellent catering arrangements organized at the Institute by Mrs. R. M. Lister, Mrs. W. P. Mowat and Mrs. C. E. Taylor, and to the fact that the wives of visitors were so ably looked after by Mrs. A. R. Wilson. To these ladies and to all the other members of staff who generously gave help and hospitality, we are much indebted. Particular thanks are due also to the staff of the Laboratory Service Department, and especially to Mr. Sunderland, the Institute photographer, for their artistic and effective staging of the exhibits provided both by our own staff and by the visitors.

PROGRAMME OF SYMPOSIUM ON SOIL-BORNE VIRUSES

8th July

Chairman—Mr. F. C. Bawden, F.R.S.

Welcoming address by the Director.

Introduction by the Chairman.

Soil-borne viruses as plant pathogens. C. H. Cadman.

The ecology and dissemination of soil-borne ringspot viruses. R. M. Lister.

Some interactions of virus, vector and soil. B. D. Harrison.

Transmission of arabis mosaic virus by nematodes (*Xiphinema diversicaudatum*). A. F. Posnette and A. Jha.

Studies of soil-borne virus diseases of grapevine in California vineyards. W. B. Hewitt, A. C. Goheen, D. J. Raski and G. V. Gooding, Jr.

Sap-transmissible viruses associated with diseases of grapevines in Europe and North America. H. F. Dias.

9th July

Chairman—Dr. B. Kassanis

Tobacco necrosis virus in the Netherlands. D. Noordam.

Tobacco rattle virus in Germany. E. Brandenburg.

Some experiments and observations on soil-borne viruses in bulbous crops, in particular tulip, hyacinth, narcissus and crocus. D. H. M. van Slogteren.

New aspects of rattle virus and its transmission. H. H. Sol.

Chairman—Dr. C. H. Cadman

The behaviour of tobacco stunt virus in soils, particularly supposing *Olpidium brassicae* as the vector. Z. Hidaka.

Soil-borne small-grain viruses in the United States. W. H. Sill, Jr.

LIST OF VISITORS

Mr. F. C. Bawden, F.R.S., Rothamsted Experimental Station, Harpenden, Herts.

Prof. E. Brandenburg, Institut für Phytopathologie, Ludwigstr. 43, Giessen/Hessen, Germany.

Mr. H. F. Dias, Rothamsted Experimental Station, Harpenden, Herts.

Dr. R. W. Fulton, Plant Pathology Dept., University of Wisconsin, Madison 6, Wisconsin, U.S.A.

Mr. A. J. Gibbs, Rothamsted Experimental Station, Harpenden, Herts.

Dr. D. A. Govier, Scottish Plant Breeding Station, Pentlandfield. Roslin, Midlothian.

Dr. B. D. Harrison, Rothamsted Experimental Station, Harpenden, Herts.

Prof. Wm. B. Hewitt, Dept. of Plant Pathology, Agricultural Experiment Station, University of California, Davis, California, U.S.A.

Prof. Z. Hidaka, Hatano Tobacco Experiment Station, Hatano, Kanagawa, Japan.

Mr. A. Jha, East Malling Research Station, Maidstone, Kent.

Dr. B. Kassanis, Rothamsted Experimental Station, Harpenden, Herts.

Dr. D. Lihnell, Statens Växtkyddsanstalt, Solna 7, Sweden.

Dr. J. A. Milbrath, Dept. of Botany and Plant Pathology, Oregon State College, Corvallis, Oregon, U.S.A.

Dr. D. Noordam, Laboratorium voor Virologie, Binnenhaven 4b, Wageningen, Netherlands.

Dr. R. S. Pitcher, East Malling Research Station, Maidstone, Kent.

Dr. A. F. Posnette, East Malling Research Station, Maidstone, Kent.

Dr. I. W. Prentice, Ministry of Agriculture, Fisheries and Food, Plant Pathology Laboratory, Hatching Green, Harpenden, Herts.

Dr. D. J. Raski, Dept. of Plant Nematology, Agricultural Experiment Station, University of California, Davis, California, U.S.A.

Prof. E. Refatti, Istituto di Patologia Vegetale, via Celoria 2, Milan, Italy.

Mr. G. G. Samuel, Agricultural Research Council, Cunard Building, 15 Regent Street, London, S.W.1.

Dr. W. H. Sill, Jr., Dept. of Botany and Plant Pathology, Kansas State University, Manhattan, Kansas, U.S.A.

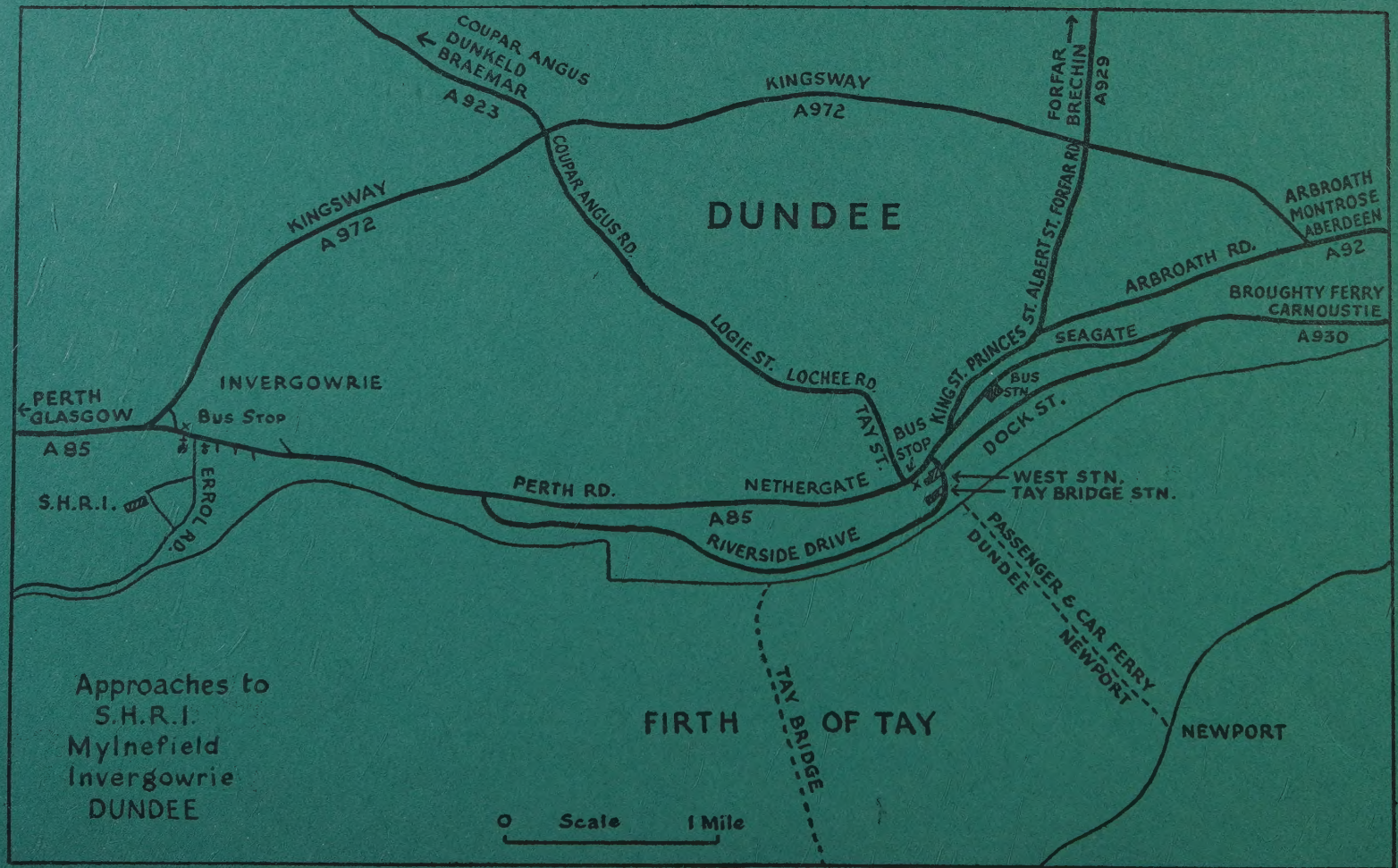
Mr. D. H. M. van Slogteren, Laboratorium voor Bloembollenonderzoek, Lisse, Netherlands.

Dr. H. H. Sol, Instituut voor Plantenziektenonderzoek, Binnenhaven 4a, Wageningen, Netherlands.

Mr. J. M. Todd, Dept. of Agriculture for Scotland, Scientific Services, East Craigs, Edinburgh, 12.

Prof. J. P. H. van der Want, Laboratorium voor Bloembollenonderzoek, Lisse, Netherlands.

Mr. A. Vuittenez, Station de Pathologie Végétale, 8 rue Kléber, Colmar, France.



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